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BASIC ELECTRONICS SKILLS AND KNOWLEDGE

Edward W. Frederickson
Durward R. Freer

Prepared By:

Applied Science Associates, Inc.
Box 158
Valencia, PA 16059

Prepared For:

UNITED STATES ARMY RESEARCH INSTITUTE
FOR BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Ave.
Alexandria, VA 22333

Monitored Technically by
ARI Field Unit at Fort Bliss, Texas
Michael H. Strub, PhD; Chief

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An analytical process for deriving skills and knowledges for an electronic maintenance MOS was developed. The process model that was developed assumes that the MOS is well documented. The process first identified all tasks performed on specifically designated equipment groups (end items) using a Task Identification Matrix (TIM). One fourth of the tasks performed on each item were selected, using various criteria, for detailed task element analysis. The task elements are validated prior to the detailed analysis. The purpose → next page

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of the analysis is to identify behaviors and knowledges not possessed by the general population. The product of the analysis is an extensive list of behavior/information statements that are used to construct a maintenance fundamentals job description questionnaire. This is then administered to a representative sample of job incumbents as a way of validating the list of job fundamentals. This information is then provided to course developers for their use in building training programs.

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LEVEL II

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BASIC ELECTRONICS
SKILLS AND KNOWLEDGE

Edward W. Frederickson
Durward R. Freer

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SECTION I
INTRODUCTION

Over the past twenty years the US Army Air Defense School (USAADS) has expressed a concern and interest in the questions of what kind and how much training the average soldier must have to perform successfully as an electronic technician. Generally the answer has been that at least two kinds of training are needed: First he must have a working knowledge of electricity/electronics; and second he must have a working knowledge of the maintenance tasks required for the system for which he is responsible. These two categories of training have been called Basic Electronics (BE) and systems training respectively.

The question of how much training is needed has tended to look at the depth of understanding that is necessary to perform the job successfully. A continual problem with this question has been that the term "perform successfully" has been defined differently by field management personnel than by school personnel. The unit commander has been driven by his pressures to keep his systems operational as much as possible, regardless of the situations. Over the years, his definition of a good technician was one who could keep the system up. It matters not that the technician must perform unauthorized tasks to accomplish this or that he must fabricate a temporary fix to substitute for a non-available component.

The technician who could perform beyond the normal and authorized level of effort was not rare. Early in the history of Air Defense systems, reference publications were, more often than not, incomplete, inaccurate, or not accessible. It became necessary to acquire not only functional knowledge and skills, but also theoretical knowledge and skills. The successful technician not only knew how a piece of equipment worked, he also found out why. He often had the performance capabilities of a design engineer.

These conditions have created a historically derived perceptual set that technicians can always use a more theoretical understanding of why an electronic system operates. This set has led to considerable research over the past two decades. Much of the work has been focused on how best to teach BE. The Functional Context approach to training was designed as a way of increasing the meaningfulness of BE. The Hawkeye approach developed by HumRRo in the 1960's (Hawkeye, 1969), integrated basic troubleshooting concepts into a job aid. The multi-level training system (Foster, 1972) was another attempt to integrate theory, training, and experience in the development of technical expertise. However, front-end-loading of electronic training with BE has tended to prevail in some form. The traditional instructor-taught class and laboratory approach has been the one most often used. The development of a common BE preparation course, COBET given prior to a more specific BE concept course was attempted, but was discontinued.

Numerous studies have been done over the past three decades by all services in an effort to reduce the complexity and the cost of electronic maintenance training while producing more competent technicians. These studies have demonstrated repeatedly that enormous savings are possible when the resultant training is based on a detailed analysis of the job. Elliott (1966, 1967) and Elliott and Joyce (1968, 1971), demonstrated that "electronically naive" high school students with as little as 13 hours of self-paced instruction could solve between and within-stage electronics troubleshooting and repair problems in far less time and with fewer diagnostic errors than conventionally training journeyman Air Force electronic technicians.

Pieper (1968 and 1969) demonstrated that well designed courses of shorter length (15 versus 24 weeks) could produce higher proficiency graduates in a modified F-111A weapon control system technician course. Significant additional course cost reductions were also achieved through substitution of simulators for expensive and scarce tactically configured equipment. Requirements for instructors were also significantly reduced through self-pacing.

Part of the savings which these and other studies have demonstrated resulted from, 1) changes in instructional approach, 2) changes in mode of presentation, 3) the use of simulators which provided more and more valid task practice, and 4) novel types of performance aids which simplified the tasks making them both easier to perform and easier to learn. Yet, a common thread runs through them all. They are all based on a careful examination of what the job incumbent does on the job and restriction of course content to only material functionally related to job content. In almost every case, it has been possible through systematic task identification and analysis to define a list of skills and knowledge necessary and sufficient for job task performance, limit training content to that list, and demonstrate large savings in course costs and increased end-of-course proficiency. The most prominent training content casualty associated with the approach has been "Electronic Theory" or "Basic Electronics"; the body of knowledge which explains at the electron flow level of abstraction how the equipment does what it does, including the mathematics which describes quantitatively both the static and dynamic transfer functions. Only reluctantly have the schools allowed the BE content to be considered for modifications. The belief is widespread that "a thorough grounding in the fundamentals" leads 1) directly to rapidly accelerating skill acquisition on the job, 2) ultimately to higher levels of proficiency, 3) to maximized transfer of training and thus to greater versatility of the job, 4) to more successful career progression, 5) to better personnel retention, 6) greater maturation through professional pride, and on and on. Has there been any truth in this? The history of the research has provided some support for both sides of the issue.

Nevertheless, the latter views regarding BE have been widely held by senior NCOs and by Commanding Officers in the field who have responsibility for maintenance, by school instructors both military and civilian and by school course developers. On the other hand, the savings demon-

strated by those studies which altered BE content and mode of instruction are real and repeatable.

Most of the successful repetitions have occurred when researchers (like ARI and its contractors) have done the analyses and developed the course materials. When the schools have done it, the typical pattern has been to make changes, try them out and then to return to the old way. Courses have been shortened with, presumably, some cost savings; but the hoped-for improvement in proficiency did not materialize. In all services, the typical result has been an eventual return to theory based courses due in part to pressure from the field for more training in basic electronics. This pressure was readily acceeded to by the school staff who were predominately of the opinion that more basic electronics is better in the long run and who, perhaps more importantly, believed that their opinion has been validated by the data.

Some studies conducted by various agencies have used questionnaires as a means of obtaining feedback from the field concerning the assessment of training needs that could be met in the USAADS. This feedback has more often than not been opinion based, and biased by the previously described perceptual set of senior NCOs and commanders. There appeared to be different definitions of the term "theory" by the various responders.

This report describes a research effort that has addressed both the "what kind" and "how much" training questions for three MOS's, 24E Improved HAWK Fire Control Mechanic, 24H Improved HAWK Fire Control Repairman, 24J Improved HAWK Pulse Radar Repairman. The specific issue concerned was the development of an analytical process for deriving basic electronic skills and knowledge that underlie the technical job performance for these electronic maintenance MOS's. Earlier efforts by the USAF (O'Connor, 1975) attempted to achieve the same end but from a school content origination of job descriptions. The USAF assemption apparently was that all skills and knowledge that could possibly be required on the job were already included in existing course POIs. The purpose of the USAF

effort was seemingly to be able to eliminate unwanted and irrelevant content from the school courses.

The position taken in the project reported here was that for the USAADS to realize the maximum benefits of job-oriented electronics maintenance training, a method for determining what to train, especially with reference to basic electronic content, should be derived from an analyses of the actual jobs to be performed. What the student needs to be able to do on the job is purely an empirical question. However, the empirical approach to obtaining this information is time consuming, costly and requires extensive use and coordination of personnel and equipment resources. The purpose of this project, therefore, was to develop task analytical procedures, derived from an empirical approach, for determining fundamental skills and knowledge required in the performance of electronic maintenance jobs. Accordingly, the following objectives were established for achieving this purpose:

1. Identification of the task content of jobs at various maintenance levels.
2. Identification of requisite skills and knowledge for electronic maintenance tasks.
3. Development and validation of measures of electronic maintenance skills and knowledge.
4. Development of guidelines for course developers.

Overview and Rationale for Research Approach

The assumption underlying this project was that an analytical process for deriving skills and knowledge for electronic maintenance jobs could be developed that had empirical validity. If this could be shown to be true, considerable amounts of resources and time could be saved in designing maintenance training which focused on only job relevant skills and knowledge in training. In order to ensure the validity of the analytical products, the process began with a job description and finished with an evaluation of incumbent job performance. A sequential

process was developed that first studied an entire job for an MOS. The job had previously been broken into tasks, using the Instructional Systems Design (ISD) (TRADOC PAM 350-30) definition of a task - an activity that has an identifiable beginning and end serving some meaningful purpose. Tasks were then broken into elements following the ISD process. A task element was defined as an activity (procedural step) that is performed only as part of the effort to accomplish the task objective. The isolated performance of a task element serves no meaningful purpose in and of itself. Since the ISD process essentially ends the task analysis at this point, a set of analytical procedures were developed for further analyzing task elements. Most job description reports do not present information of exactly how each task element is carried out. This was true of the MOS Data Bank (MOD-B) report for the MOS's studied in this project. The CODAP program used to analyze the MOS data was not designed to answer training design questions. Therefore, the use of the MOD-B reports for training design required several assumptions about exactly how the job was performed at the task element level of description from which skills and knowledge statements are derived. In this project each task element was examined following a sequence of analytical questions. After all tasks were analyzed to the skills and knowledge level, the results were assimilated to determine the most commonly occurring skills and knowledge. This kind of information is the desired input to training program design. When the course developer has a description of exactly which skills and knowledge are actually applied at the task element level he can design a more relevant training course.

A skill was defined here as an activity that cannot be readily performed by the general population. It is an activity that would not be found in the behavior repertoire of most people. A skill would be an activity that required practice before it could be successfully performed. It could not be carried out by simply following instructions. Knowledge was defined as information that must be recalled or recognized before a subsequent activity could be carried out. It may be

information about how to do something, where something is located or a specification/standard against which other information must be compared.

The products of the task element analysis - lists of skills and knowledge were used as the basis for a job description questionnaire. The assumption was made that if the analytical process for identifying basic skills and knowledge was valid such a questionnaire should produce a majority of positive responses to questions about their application. The development and administration of this Basic Electronic Skills and Knowledge (BESK) questionnaire was the first of a two step validation process.

The second step involved the construction and administration of a job performance test. The performance test was used as an additional means of confirming the results of the analytical process for determining basic skills and knowledge. The assumption was that if the analytical process produced valid results the most successful and more experienced job incumbents would perform better on the test than the least successful and less experienced. The test was therefore administered to samples of electronic maintenance technicians with varying amounts of experience and different ranks.

The final step of the project was to outline the analytical process as guidelines for course developers at the USAADS. The responsibility for the application of the task analytical process has not been established, but the results of the analysis will definitely serve as input to the design of maintenance training courses, at least at the level of course content decision making. ok

The task analytical process was not designed to include all tasks in the analysis. One of the fist steps was to select representative tasks of the MOS. This was accomplished by estimating task complexity and determing the amount of duplication of tasks in the job. Task uniqueness in terms of the kinds of components was also considered. The task selection procedures were instituted because of the time

restrictions on this project, but a modification of these procedures was included in the final guidelines.

The last point to cover in this section deals with the original requirement to determine electronic maintenance task content across skill levels within an MOS. The training and operations reality is that there are two skill levels in electronic maintenance - qualified to perform maintenance and not qualified. The USAADS trains to one skill level - qualified. The field maintenance supervisors and unit commanders do not differentiate between EPMS skill levels 2 and 3 in terms of maintenance job activities. The only differences are found in non-maintenance activities, those more related to the supervisor role. However this study of the maintenance level concept did deal with two kinds of electronic maintenance MOS's within the Improved HAWK System that imply different kinds of skills or at least different kinds of maintenance orientation. These are the mechanic and repairman technicians. But these are not part of one career progression ladder. Within these two MOS's many maintenance tasks overlap and many do not. The mechanic is system operation oriented. The repairman is chassis function oriented. The mechanic repairs and troubleshoots down to but not within the chassis. The repairman usually begins where the mechanic left off. The repairman repairs and troubleshoots down to the component level. Both, generally, must have the same kinds of fundamental electronic skills and knowledge to perform their jobs. The mechanic does have to have more knowledge of how the complete system operates.

In addition to including the two maintenance orientations as independent variables, it was decided that electronic maintenance experience would be looked at to determine whether proficiency, and thus skill level might be related to years of experience.

SECTION II

RESEARCH APPROACH

The report has been organized around the discussion of each of the tasks. Each discussion presents first a description of what the task was and how it was carried out. Second, there is a discussion of the results that were obtained, and last a summary of conclusions that were reached. Task 1, 2, and 3 each produced results that served as inputs to each subsequent task. Task 4 produced an outline of how to use the task analytical process model in deriving fundamental skills and knowledge that are subordinate to electronic maintenance task performance in the 24E, 24H, and 24J MOS's. The body of the report presents a description of the research project and the analytical and empirical results. Actual research instruments and products are presented in the Appendices.

Overview of the Development of Task Analytical Process Model

The research objective of developing a Task Analytical Process Model (TAPM) for deriving fundamental skills and knowledge for electronic maintenance jobs was first analyzed for project planning. Because of the sheer magnitude of a complete analysis of all job tasks, it was deemed desirable that the process model be able to reduce the size and complexity of such an effort as much as possible and still produce complete and valid results. There are several thousand tasks that qualified technicians must be able to carry out in the maintenance of the equipment for which they are responsible. Many tasks are redundant to a great degree. For example, relay assemblies are used throughout the HAWK system in different equipment end items and chassis. The primary difference in the tasks of repairing different chassis by replacing a relay assembly deals with the specific function and location of each assembly. Since the underlying skills and knowledge that are relevant to working with an identical component are the same, the decision was made to analyze only once these tasks involving the replacement of identical components even though the components occurred at many different locations.

This preliminary thinking led to the conclusion that the model should include procedures for selecting representative tasks for detailed analysis. Task 1 was concerned with the process of identifying, evaluating and selecting representative tasks. The procedures for performing each selected task(s) were validated before the detailed analysis could be conducted. Tasks were selected for analysis using a definition of criticality that included density of performance, impact on readiness status and frequency of malfunction occurrence.

With an input of validated task procedures, Task 2 was concerned with the application of the analytical model process procedures. A list of job activities was compiled and coded as each task element was examined. Only activities that could be classified as skills or the recall and recognition of information (use of knowledge) were listed. Task 2 was completed by summarizing the number of times each skill or use of knowledge occurred in the performance of the selected tasks. The development and application of the TAPM was documented so as to prepare a set of guidelines for use of the TAPM by course developers.

Task 3 was a study to validate the use of the TAPM. A performance oriented test involving the use of electronic maintenance fundamentals was developed and administered to samples of technicians in each of the MOS's. The test content was based upon the products of the TAPM analysis. Each test participant was rated by his supervisor on a set of external performance criteria. His performance test results were then compared with these ratings.

Task 4 consisted of the preparation of a set of guidelines on how to use the Task Analytical Process Model. It described how to construct a Task Identification Matrix (TIM).

<u>Electronic Maintenance Task Analysis</u>

The purpose of this first task was to develop a method for selecting representative maintenance tasks. Since the MOS's selected as vehicles for this study were well documented, it was decided that a cost

effective approach would be to use the already published materials as a starting point. Table 1 presents a list of the documents that were assembled for review.

Table 1

Documents Reviewed for TIM Preparation

MOS	Document Number and Title
ALL	AR-220-1 Missile System Availability Indicator
ALL	AR-611-201 Career Management
ALL	TM-9-1425-525 ESC Equipment Serviceability Criteria Improved HAWK
ALL	TM-9-1425-525-12-4 General Maintenance
ALL	TM-9-1425-525-34 General Maintenance
24E, 24H	TM-9-1430-526-12-1 Improved Battery Control Central AN/TSW-8
24H	TM-9-1430-526-34-1 Units of Improved Battery Control Central AN/TSW-8 Tested at High Frequency Console
24H	TM-9-1430-526-34-2 Improved Battery Control Central AN/TSW-8
24E, 24H	TM-9-1430-526-24P Improved Battery Control Central AN/TSW-8
24E, 24J	TM-9-1430-534-12-1 Improved Radar Set AN/MPQ-50
24J	TM-9-1430-534-34-1 Units of Improved Radar Set AN/MPQ-50, Tested at High Frequency Console
24J	TM-9-1430-534-34-2 Improved Radar Set AN/MPQ-50
24E, 24J	TM-9-1430-534-24P Improved Radar Set AN/MPQ-50
24H	TM-9-1430-527-12-1 Information and Coordination Central AN/MSQ-95
24H	TM-9-1430-527-12-3 Fault Isolation Information and Coordination Central
24H	TM-9-1430-527-24P Information and Coordination Central AN-MSQ-95
24E, 24J	TM-9-1430-529-12-1 Improved Radar Set AN/MPQ-51
24E, 24J	TM-9-1430-529-34-1 Units of Improved Radar Set AN/MPQ-51 Tested at High Frequency Console
24J	TM-9-1430-529-34-2 Improved Radar Set AN/MPQ-51
24E, 24J	TM-9-1430-529-24P Improved Radar Set AN/MPQ-51

Development of the Task Identification Matrix (TIM)

The first decision that was made in Task 1 was to limit the study to major equipment end items that were common across the mechanic and repairman jobs. Because of limited contract time it was not possible to include all equipment and items in this study. However, a full blown use of the TIM would include all system equipment for analysis. The two major equipment end items included in this project were:

Improved Battery Control Central (IBCC)

Improved Pulse Acquisition Radar (IPAR)

The 24E mechanic has responsibilities for both the IBCC and IPAR. The 24H repairman is responsible for the IBCC and the 24J for the IPAR.

When the description of the hardware items for the Air Defense System are thorough and complete the TIM should begin with a listing of equipment items down to the lowest level of authorized repair. In each end item there is a point in the breakdown of the equipment into subunits (chassis, components, or parts) where only replacement of the unit is authorized. Repair of that unit would not be authorized at the designated echelon where a job incumbent is assigned. The information about the authorization for maintenance is found in two places:

1. the Maintenance Allocation Chart in the TMs; and
2. the Parts Manuals.

In this project the information was obtained from:

TM-9-1430-526-24-P Improved Battery Control Central AN/TSW-8, Section II-Column 2-pages 2-1 through 2-207.

TM-9-1430-526-12-1 Improved Battery Control Central AN/TSW-8 Appendix B pages B-1 through B-5.

TM-9-1430-534-24P Improved Radar Set AN/MPQ-50, Section II Column 2, pages 2-1 through 2-168.

TM-9-1430-534-12-1 Improved Radar Set AN/MPQ-50, Appendix C pages C-1 through C-19.

The listing of equipment should next be grouped in some logical manner. Either a hardware grouping or a functional subsystem grouping

could be used. It was decided that the hardware grouping would work more efficiently with the IBCC and IPAR. As the subunits are placed in their appropriate group a check is made to see if the same kind of subunit had already been listed. The idea is to eliminate duplicate listing of the same kind of equipment. Since the tasks to be performed on these would be very similar, no purpose would be served by listing all individual subunits. Appendix A presents the equipment item listing in the form of a Task Identification Matrix for the IBCC and IPAR. It should also be noted that the number of duplications of each subunit is indicated in the first column following the item name.

The second step was to determine the kinds of task activities that mechanics and repairmen perform on the equipment for which they are responsible. Again the published documentation was reviewed to identify the maintenance activities that are to be performed. It was determined that there are four general categories of maintenance activites.

1. Periodic Checks
2. Preventive Maintenance
3. Malfunction Diagnosis (Troubleshooting)
4. Corrective Maintenance

Each of the categories requires various kinds of tasks be performed. Some tasks are required to be performed in more than one category. Table 2 presents a list of twelve different tasks. Two of these are seldom performed by the 24E, 24H, and 24J technicians - overhaul and rebuild. Of the remaining tasks there is some difficulty in meaningfully separating the activities. For example a larger unit may be <u>repaired</u> by replacing, aligning, and adjusting a smaller unit. The first administration of the complete TIM (the equipment items within groups listed vertically with tasks across the top horizontally) led to a revision where only the categories were used across the top. It was pointed out that if a technician performs one of preventive maintenance tasks, he almost always performs the others. This modification was made as a concession to data

Table 2

Definition of Maintenance Task Verbs

Inspect:	To determine the serviceability of an item by examining its physical, mechanical and/or electrical characteristics and comparing the state of these characteristics with established standards. (Also to examine and to perform preventive maintenance.)
Test:	To verify serviceability of an item by measuring its mechanical and/or electrical characteristics and comparing these measurements with established standards. (Also to detect functional failure, to evaluate and to check.)
Diagnose:	To isolate a malfunctioning item (component, module, subassembly or assembly) that is the source of operational failure. (Also to troubleshoot.)
Service:	To perform operations, such as cleaning, charging, and adding fuel, lubricants, cooling agents and air, on a periodic schedule to keep a system in proper operating condition. (Also to perform preventive maintenance.)
Adjust:	To bring an operating characteristic of an item into prescribed limits by setting variable controls to the specific, proper or exact positions.
Align:	To adjust specified variable elements of an item to bring about optimum or desired functional performance.
Calibrate:	To detect and adjust any discrepancy in the accuracy of an instrument (measurement or diagnostic equipment) when compared to an instrument which is a certified standard of known accuracy.
Install:	To seat or fix into position an item (component, module, subassembly or assembly) in a manner to allow the proper functioning of equipment or a system. (Also to emplace.)
Replace:	To remove a non-functioning item and to substitute a serviceable like-type part, subassembly, module (component or assembly) in a manner to allow the proper functioning of an equipment/system. (Also to assemble and disassemble.)
Repair:	To restore an item to serviceable condition. Consists of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions

(welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to correct specific damage, fault, malfunction, or failure in a part, subassembly, module/component/assembly, end item or system.

Overhaul: To restore an item to a completely serviceable/operational condition as prescribed by maintenance standards. This is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

Rebuild: To restore unserviceable equipment to a like-new condition in appearance, performance, and life expectancy. This is accomplished through complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements (items) according to original manufacturing tolerances and specifications, and subsequent reassembly of the item. Rebuild is the highest degree of material maintenance applied to Army equipment.

collection validity. The original TIM for the IBCC had over 1200 cells each of which represented a task. When job incumbents were asked to check each cell and indicate whether they performed the task and if so how often, they felt overwhelmed. Some respondents required several hours to fill out the form. Others just got it over with as quick as possible. Job incumbents felt the modified form was less cumbersome.

Administration of the TIM

The TIM was constructed as an instrument to be used for identifying the tasks actually performed in an MOS and to gather information for input to the decision as to which tasks should be considered for detailed analysis. The TIM was first tried out administratively. Other than being cumbersome, it was found that the original list of interview questions used with the TIM had to be changed. Each of the following questions was asked during the administrative tryouts:

1. Which of the tasks in the TIM have you performed?
2. Do you use any other names (verbs) when referring to these tasks?
3. How often do you perform each of these tasks?
4. When you are performing these tasks, approximately how much time (hours) is required to complete each task?
5. If each task was not performed, what impact would there be on the operational readiness (green, amber, or red) of the system?
6. How long after your first assignment to a maintenance duty position were you required to perform each task?
7. How long did it take you to learn to perform each task?

It was found that questions 4, 5, 6, and 7 could not be answered meaningfully. The time it takes to perform a task varies with the situation and conditions. Only a few of the most experienced technicians could respond to the readiness impact question. Since the operational readiness of a system is established formally, it was decided to refer this question to the official classification scheme. Number 6 became irrelevant since the answer was confounded with the specific kind of experiences a technician had. The learning time question was also meaningless because learning

of a single task could not be separated from learning several others of a similar kind. Thus, as a result of the administrative tryout, questions 4-7 were deleted.

The TIM was next given to 20 technicians, ten mechanics and ten repairmen. The sample represented a diverse population in terms of rank, experience, length of service, age and education.

The results indicated many similarities in the kinds of maintenance activities actually performed on the job between the mechanics and repairmen. Some of this overlap was found to be due to the performance of unauthorized maintenance tasks on site. It was indicated that in many situations mechanics had to perform unauthorized repairman tasks under command pressure to keep the system operational. Other similarities are due to the fact that the repairman is authorized to perform almost all tasks that the mechanic performs.

Definite differences were also noted between the mechanic and repairman MOS's. In the interviews the mechanics indicated they use more mechanical than electronic skills, whereas the repairmen reported using more electrical than mechanical skills. The mechanic more often only removes or replaces entire units, whereas the repairman will repair the same unit.

Specifically, the results of the TIM interviews were that ten IPAR tasks had been performed at least ten times by 100% of the 24Es. All but one of the 24Js had also performed all ten of these maintenance tasks on the IPAR chassis listed below:

Functional Group Number	Chassis Name
1060	Dickie Fix Amplifier
1070	Dickie Fix-Fix Amplifier
1090	Interference Blanker
2405	MTI Video Amplifier and Multivibrator
2415	Carrier Generator

2425	Delay Amplifier
2435	COHO Oscillator Assembly
2455	MTI Amplifier
2605	Voltage Regulator
2620	Reference Voltage Regulator

Eighty percent of the 24E and 24H participants reported having performed various kinds of maintenance tasks ten times or more on the IBCC chassis listed below:

Functional Group Number	Chassis Name
1400	Tactical Control Console
1470	14KV Power Supply
1600	Video Amplifier
2710	10KV Power Supply
2760	Video Amplifier
2985	Scan Servo Assembly
3500	Reference Voltage Regulator
4260	Automatic Test Set
5010	TCC/TC Video Mixer
5150	TCC/FC Clamp Gate Generator
5190	Symbol Generator
6195	Range/Speed Indicator
6610	Range Electronic Control Amplifier
6710	Elevation Electronic Control Amplifier
6780	Azimuth Electronic Control Amplifier
6930	ROR Video Amplifier
7010	ROR Sweep Generator
7110	ROR Electronic Control Amplifier
7290	Scan Servo Amplifier
8600	TCO/TCA Communications Unit

Respondents completing the TIM were asked for additional job related information. A copy of this questionnaire is provided in Appendix A.

The responses to the questions indicated that personnel in the 24E MOS spent fifty percent of their time performing supervisory or administrative duties and fifty percent of their time performing "Hands on Maintenance". Personnel in the 24H and 24J MOS spent forty percent of their time performing administrative or supervisory duties and sixty percent of their time performing "Hands on Maintenance".

The majority of the respondees in all MOS's indicated they learned to operate and use the test equipment on the job. Many respondents claimed they were not taught in school to use the particular test equipment that they subsequently used on the job.

Selection of Tasks for Detailed Analysis

Task 2 was conducted for the purpose of selected high density, critical and representative tasks for the detailed analysis. The TIM provided the density data in terms of the most often performed tasks by a majority of the technicians.

Criticality data was obtained from two sources, equipment readiness status and high failure rates. First, the operational readiness criteria from AR-220-1, Missile System Availability Indicator, and TM-9-1425-525 ESC, Equipment Serviceability Criteria Improved HAWK, was applied to each equipment item rather than to each task. The rationale was that if preventive maintenance and periodic checks are not performed, a debilitating problem might occur or go undetected that could lead to red-lining the system. Also, if a problem does occur to cause a system to be down, troubleshooting and corrective maintenance must be performed to get the system back on the air. Therefore, if a technician cannot perform any maintenance task when it must be performed, the operational readiness criteria for classifying the equipment status comes into play. The operational readiness criteria were applied to all items and the results are shown in Appendix A in the last column of the TIM. These results were not as helpful in narrowing the list of critical tasks as much as was the failure rate data.

Second, the US Army Missile Material Readiness Command at Redstone Arsenal has been collecting malfunction and time-to-repair data for Improved HAWK battalions in Europe over the last year or so. Table 3 presents the data from a 1977 report of the most frequently failing items in the IBCC Fire Control Console and Tactical Control Console and the IPAR. These data were being collected on a continual basis at the time of the preparation of this report.

In addition to the criticality data, one other kind of information was used for the task selection decisions. A review of the higher density tasks was conducted by a project staff member with over twenty years of electronic maintenance experience. His review had the purpose of designating those several tasks that required the same kinds of maintenance procedures. This review was made keeping in mind the lists of tasks indicated by the malfunction and time-to-repair data. The final list of tasks selected for analysis is presented in Table 4. A total of 21 tasks was selected. The second column in Table 4 indicates the number of other tasks similar to the listed task. For example, the first task is similar to 24 other tasks performed by the 24E and 24J technicians. The 21 tasks that were analyzed represented a total of 270 tasks.

Table 3

Most Frequently Malfunctioning Equipment

(Extract From US Army Missile Materiel Readiness Command Data Bank Report)

Major Item: IPAR

Functional Group Number	Nomenclature	Organizational Maintenance No. Failed	Organizational Maintenance % Failed	Organizational Maintenance MTTR 1/	Direct Support Unit No. Failed	Direct Support Unit % Failed	Direct Support Unit MTTR
4600	Pressurization Unit	31	13.3%	.86	43	12.7%	3.69
1250	Cooler Liquid	23	9.9	1.42	24	7.1	2.25
2425	Delay Amplifier	16	6.9	1.71	34	10.1	2.9
2415	Carrier Generator	15	6.4	1.33	32	9.5	3.6
3550	High Voltage Power Supply	14	6.0	2.66	23	6.8	2.2
2465	Video Integrator	9	3.8	1.51	13	3.9	.53
4920	Modulator Sub. Assy.	8	3.4	1.64	10	3.0	1.95
2455	MTI Amp.	7	30	170	12	3.6	4.08
		2/ 123	53%		3/ 191	56.5%	

1/ MTTR = Mean Time to Repair (Hours)

2/ A total of 232 equipment failures were recorded April 1 to September 30, 1977 (182 days)

3/ A total of 338 equipment failures were recorded March 1 to September 30, 1977 (213 days)

Table 3 (cont.)

Major Item: IBCC (TCC)

Functional Group Number	Nomenclature	Organizational Maintenance No. Failed	% Failed	MTTR	Direct Support Unit No. Failed	% Failed	MTTR
2985	Scan Servo Assembly	31	16.8%	2.84	55	16.5%	3.94
3468	Voltage Regulator	17	9.3	158	19-	5.7	2.91
5310	Symbol Multivibrator	10	5.4	1.63	37	11.1	2.99
5190	Symbol Generator	9	4.9	.62	20	6.0	4.18
1600	Video Amplifier	7	3.8	1.01	11	3.3	3.11
7290	Scan Servo Amplifier	7	3.8	.75	9	2.7	2.27
1470	14KV Power Supply	5	2.7	.78	10	3.0	5.40
5410	PS1 Video Gate	5	2.7	.53	24	7.2	3.58
		81	49.71%		185	55.4%	

Table 3 (cont.)

Major Item: IBCC (FCC)

Functional Group Number	Nomenclature	Organizational Maintenance No. Failed	Organizational Maintenance % Failed	Organizational Maintenance MTTR	Direct Support Unit No. Failed	Direct Support Unit % Failed	Direct Support Unit MTTR
4730	Marker Generator	14	15.5%	.52	16	11.4%	3.27
6610	Range ECA	11	12.2	.52	17	12.1	4.04
7250	Display Generator	10	11.1	1.10	14	10.0	3.05
6710	Elevation ECA	6	6.6	.83	10	7.1	3.61
7210	Firing Interlock Assy.	4	4.4	.53	12	8.6	2.43
6780	Azimuth ECA	4	4.4	.77	6	4.3	2.83
5710	Relay Assy. (FC)	4	4.4	.88	6	4.3	2.42
		53	58.8%		81	57.8%	

Table 4

Tasks Selected for Detailed Analysis

Task Number	Number Similar Tasks	Performed by MOS	
1	24	24E 24J	Electrically aline the stabilizing system, STALO, and preselector in the Improved Pulse Acquisition Radar. (IPAR)
2	4	24E	Aline the STALO Automatic Frequency Control (AFC) in the IPAR.
3	24	24E	Aline the Scan Servo Assembly in the Improved Battery Control Central (IBCC).
4	6	24E (24H)	Replace and check out the Cathode Ray Tubes (CRT) in the IBCC.
5	4	24E	Check Firing Console in the IBCC using weekly check procedures.
6	12	24J 24H	Test the High Frequency Console using the self test procedures.
7	6	24H	Test the Display Generator at the High Frequency Console.
8	4	24H	Test the Range Speed Indicator at the High Frequency Console.
9	30	24H	Test the Scan Servo Assembly at the High Frequency Console.
10	35	24J	Test the AFC Amplifier at the High Frequency Console.
11	40	24J	Test the IF pre-amplifier at the High Frequency Console.
12	0	24J 24E	Replace the heat exchanger.
13	1	24J	Repair the heat exchanger.
14	2	24E	Replace the pressurization unit.
15	0	24J	Repair the pressurization unit.
16	36	24H	Test the 14KV High Voltage Power Supply at the High Frequency Console.

Table 4 (cont.)

Tasks Selected for Detailed Analysis

Task Number	Number Similar Tasks	Performed by MOS	
17	12	24H	Test the Symbol Multivibrator at the High Frequency Console.
18	4	24H	Test the Symbol Generator at the High Frequency Console.
19	2	24H	Fault isolate the Information Coordination Central.
20	0	24E 24J	Fault isolate the Antenna Control Circuits of the Improved Range Only Radar.
21	3	24E 24J	Fault isolate the Improved Pulse Acquisition Radar.

SECTION III

DEVELOPMENT OF THE TASK ANALYTICAL PROCESS MODEL

Most traditional approaches to task analysis have resulted in descriptions of tasks that required many assumptions of exactly how the task procedures were carried out. Training courses generated from such analytical results have been prone to errors of omission and inclusion. Some essential job skills have been omitted, while other non-relevant behaviors have been included as training subject matter.

The purpose of Task 2 was to develop an analytical process that would reduce assumptions about requisite job behaviors. The model was intended to provide a systematic and logical process for identifying basic skills and knowledge underlying successful job performance. The focus of this task was on the development and subsequent use of the process model. The Task Analytical Process Model that was developed provided a systematic approach to performing a detailed task element analysis. The assumptions that were made in using the process were:

1. Task element descriptions are valid.
2. Task element descriptions are complete.
3. The user must have sufficient job knowledge to (ask) answer the process questions.
4. The user does not have to be knowledgable in the instructional development process.
5. The user must be able to make decisions about the behavior repertoire of the general public.

The model was developed by analyzing task elements in detail from a naive point of view. The model consisted of a set of detailed questions about exactly how the task element was performed. The questions were sequential and iterative. The cyclic sequence of questioning continued until each task element was examined and a decision was made about the skill nature of the required action.

The analytical process was developed from the following general model of work activities: Input-Processing-Output. The process began with an analysis of the initiation of a task and was carried through to the completion of the task. The Input element of the general model consisted of initiating cues and situation conditions for the task. It also included the evaluation procedures that would determine when the task would be considered completed. The work flow, worker relationships and work procedures were also considered necessary parts of the Processing phase.

The Output element was defined as consisting of a finished product, which could have been a repaired, checked, serviced or replaced equipment item. A comparison of the output against the input standards would have led to a decision as to whether the activity was complete.

The sequence of steps included in the Task Analytical Process Model was structured as a flow chart presented in Figure 1.

This sequence of questions was applied to the IBCC and IPAR. It was found that there were tasks that varied in complexity from a low level to a high level as a function of the amount of implied activities. The implied activities were categorized into the following general groups:

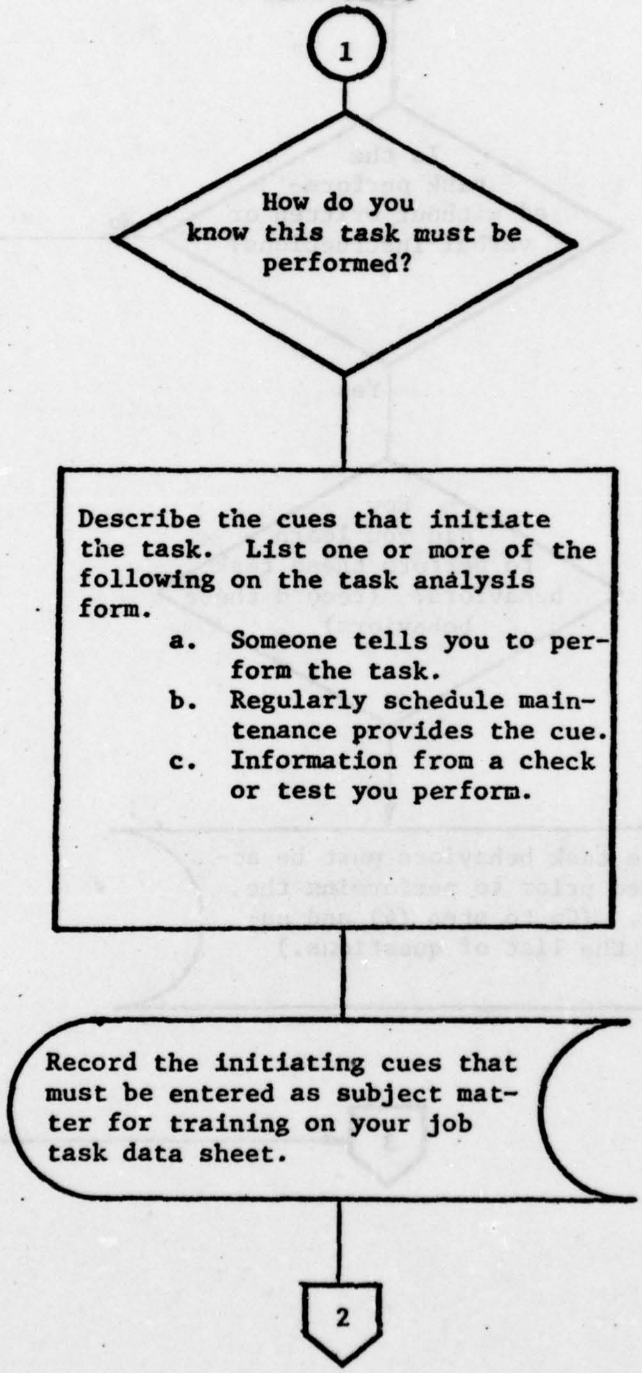
1. Skills
2. Knowledge recall and use of special information
3. System specific activities
4. Safe operating procedures
5. General work habits
6. Use of job performance aids
7. Recognition of normal and non-normal operation/cues

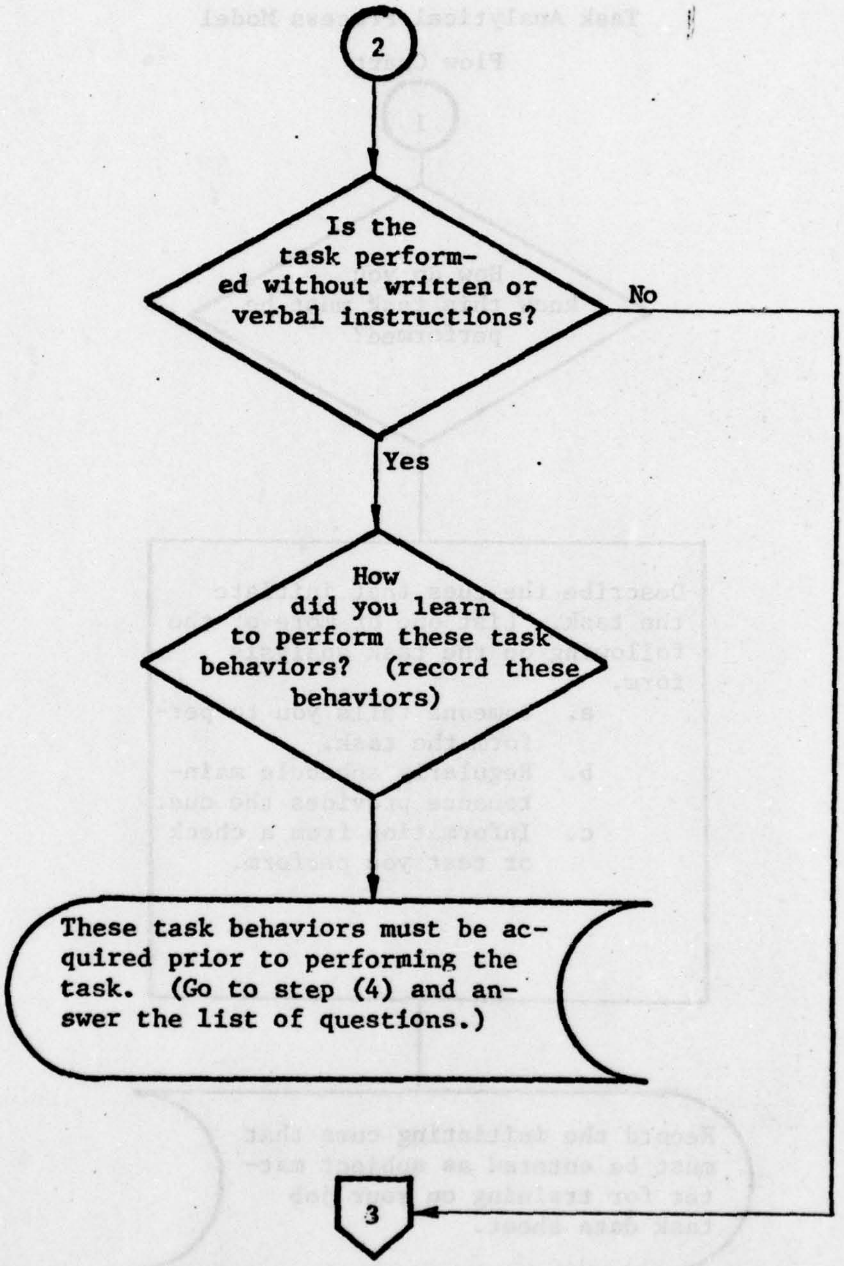
Since the focus of this study was on the determination of basic electronic skills and knowledge, the system equipment activities category was not dealt with in detail in the analyses. It should be noted, however that a qualified technician must be very familiar with the operation of his equipment, be able to diagnose system problems, and locate chassis and components within the system.

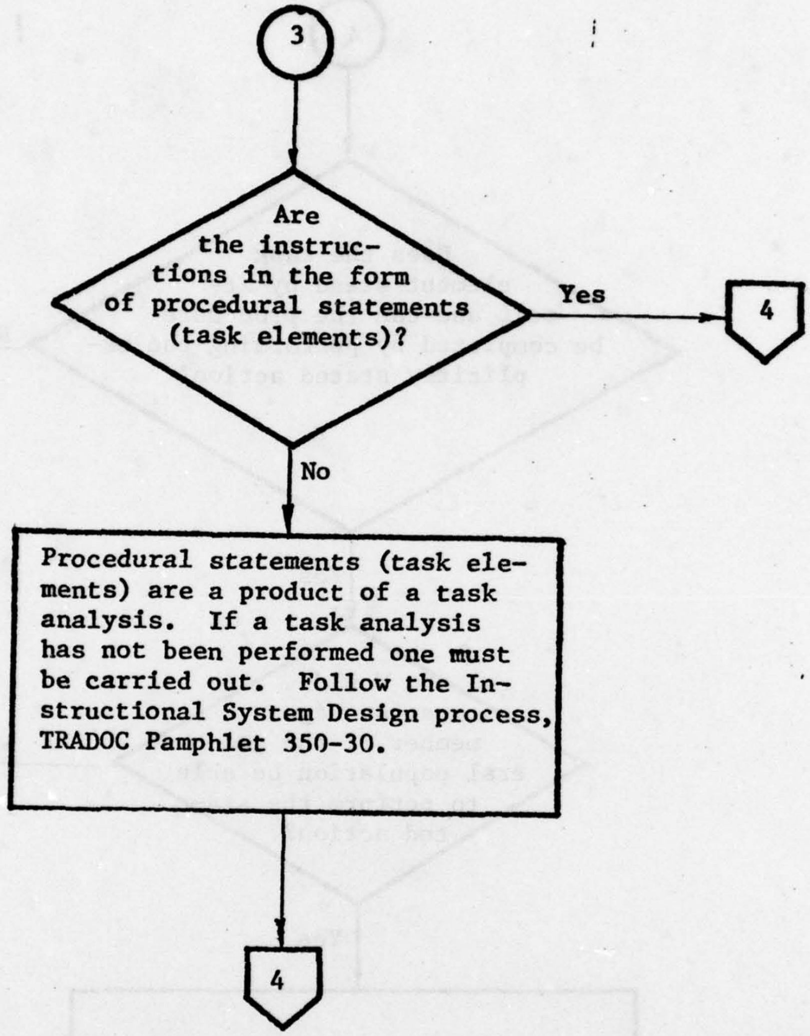
Table 7

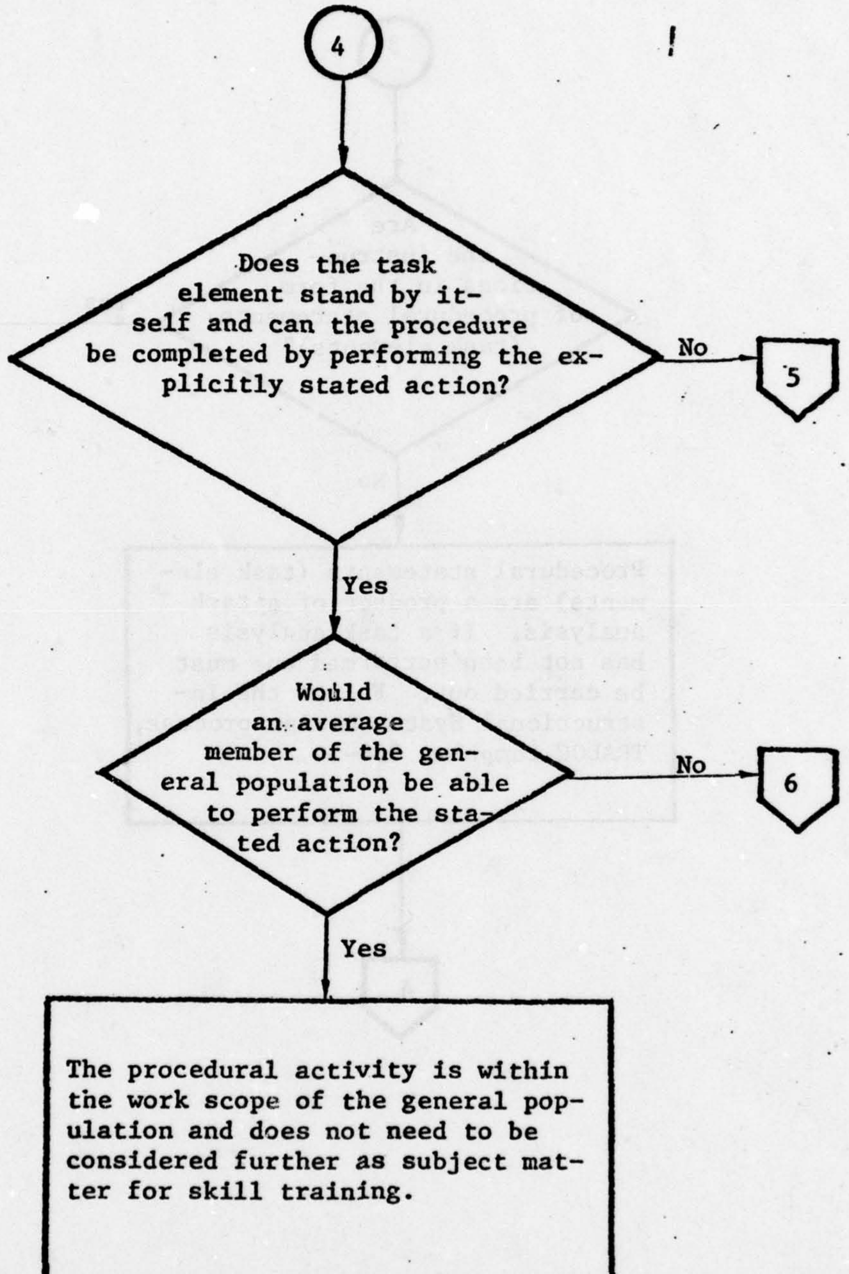
Task Analytical Process Model

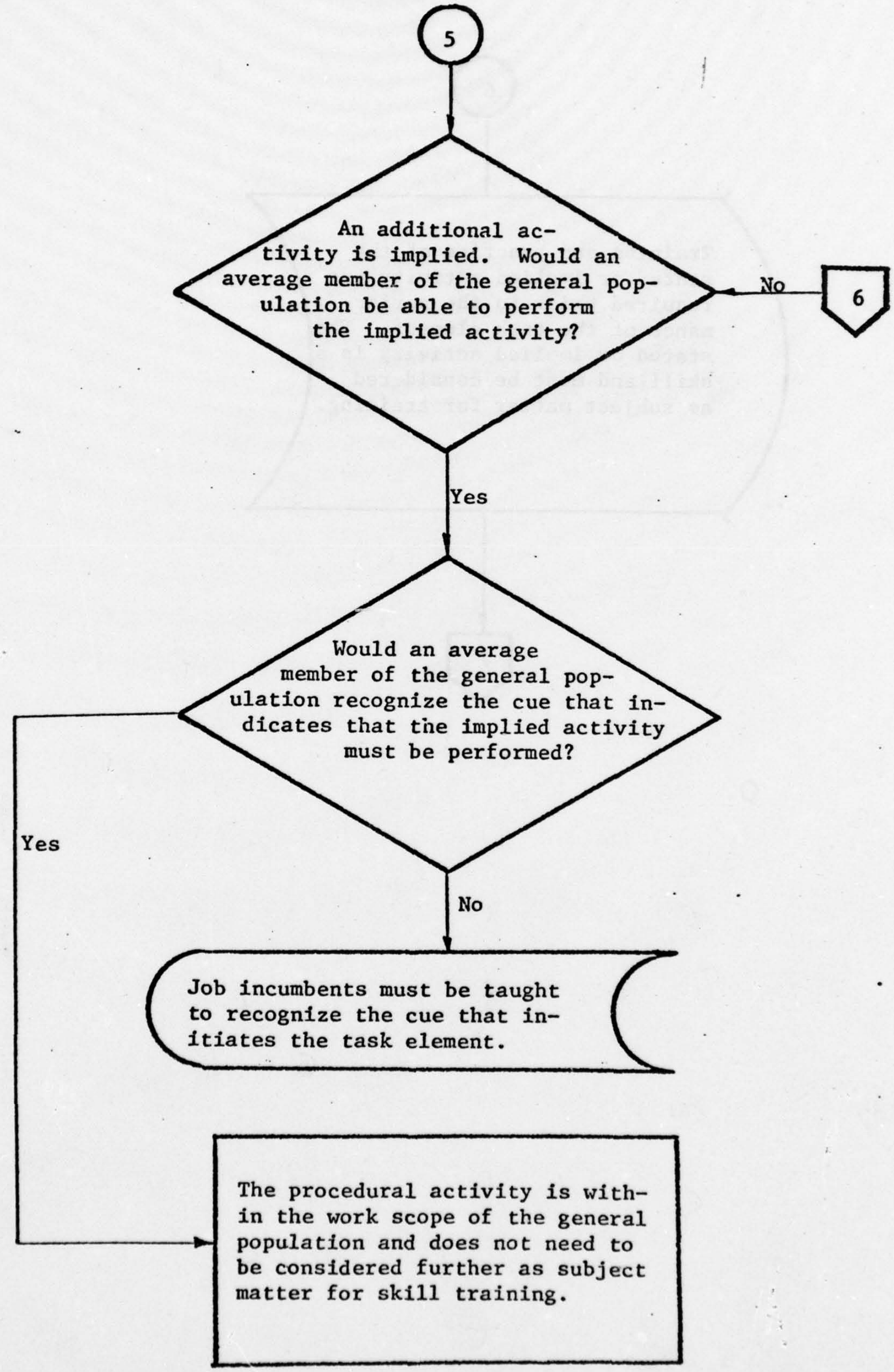
Flow Chart

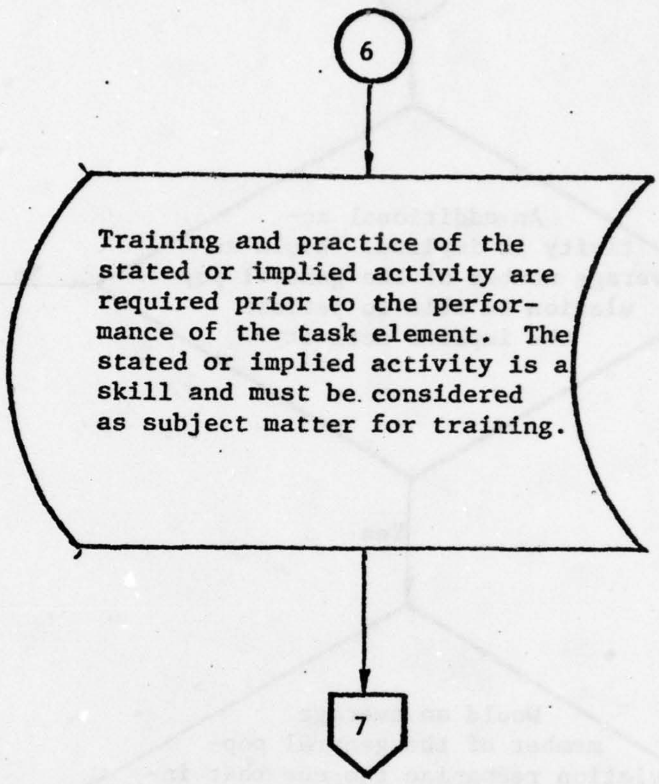



2
Is the task perform- ed without written or verbal instructions?
No
Yes
How did you learn to perform these task behaviors? (record these behaviors)
These task behaviors must be ac- quired prior to performing the task. (Go to step (4) and an- swer the list of questions.)
3


3
Are the instructions in the form of procedural statements (task elements)?
Yes
4
No
Procedural statements (task elements) are a product of a task analysis. If a task analysis has not been performed one must be carried out. Follow the Instructional System Design process, TRADOC Pamphlet 350-30.
4


4
Does the task element stand by itself and can the procedure be completed by performing the explicitly stated action?
No
5
Yes
Would an average member of the general population be able to perform the stated action?
No
6
Yes
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


5
An additional activity is implied. Would an average member of the general population be able to perform the implied activity?
No
6
Yes
Would an average member of the general population recognize the cue that indicates that the implied activity must be performed?
Yes
No
Job incumbents must be taught to recognize the cue that initiates the task element.
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


6
Training and practice of the stated or implied activity are required prior to the performance of the task element. The stated or implied activity is a skill and must be considered as subject matter for training.
7

7

Is any special information required to perform the stated or implied activity?

No → 9

Yes

Record the special information. The special information includes any indication or data that is used for deciding:

1. What procedural step must be performed next.

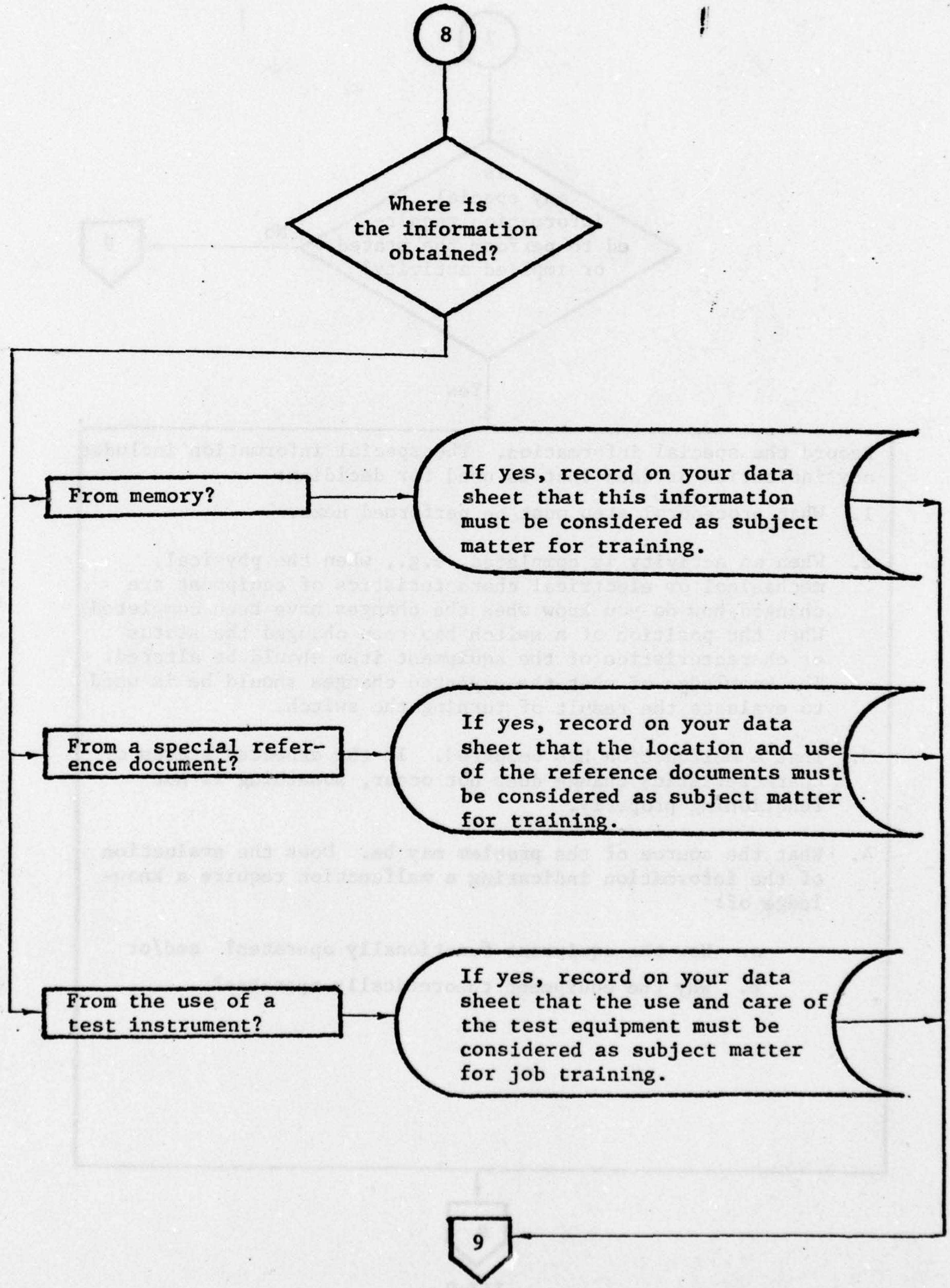
2. When an activity is completed, e.g., when the physical, mechanical or electrical characteristics of equipment are changed, how do you know when the changes have been completed? When the position of a switch has been changed the status or characteristics of the equipment item should be altered. The knowledge of what the expected changes should be is used to evaluate the result of turning the switch.

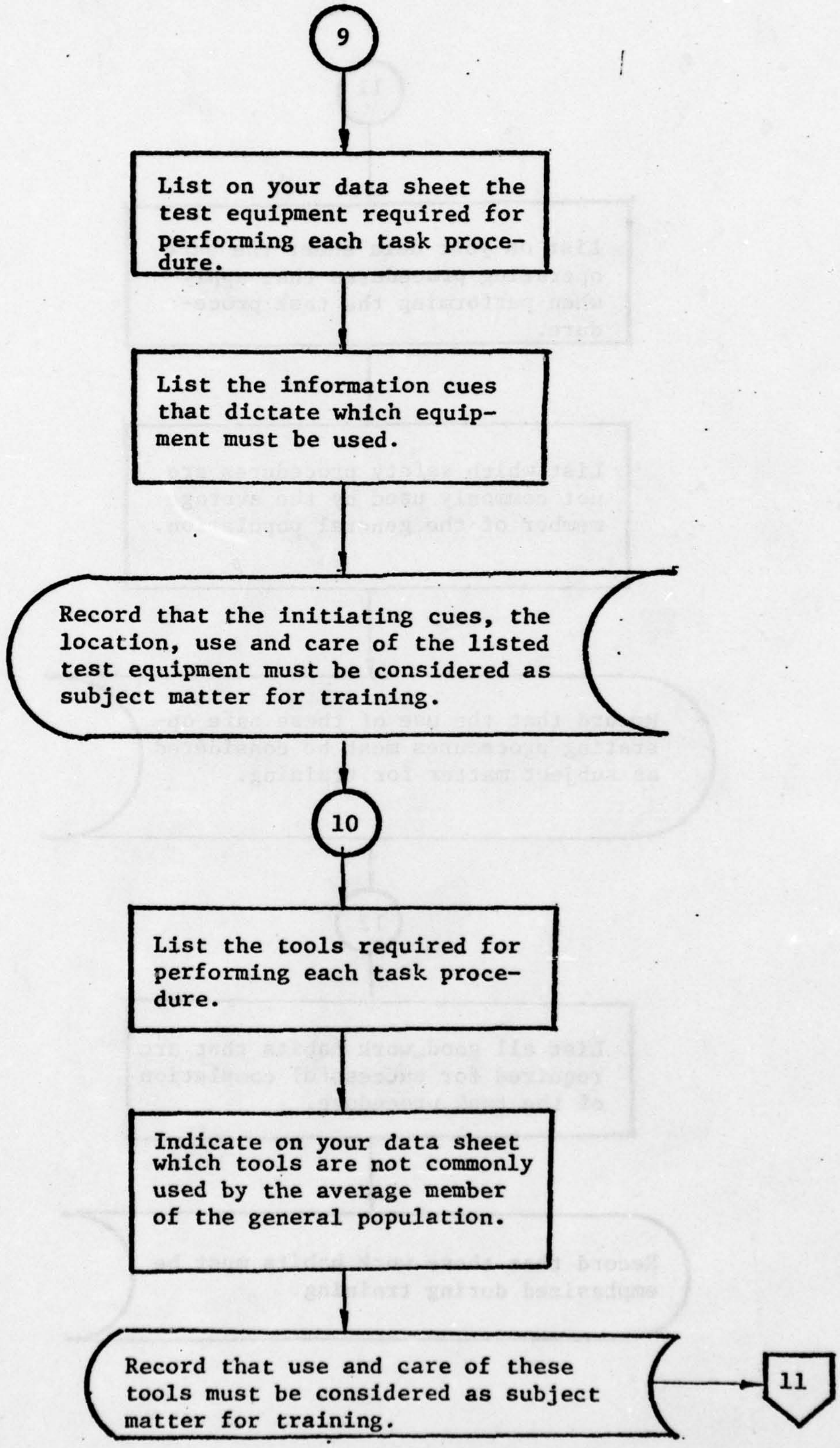
3. That a malfunction has occurred. If the expected status or characteristics change does not occur, something is not functioning properly.

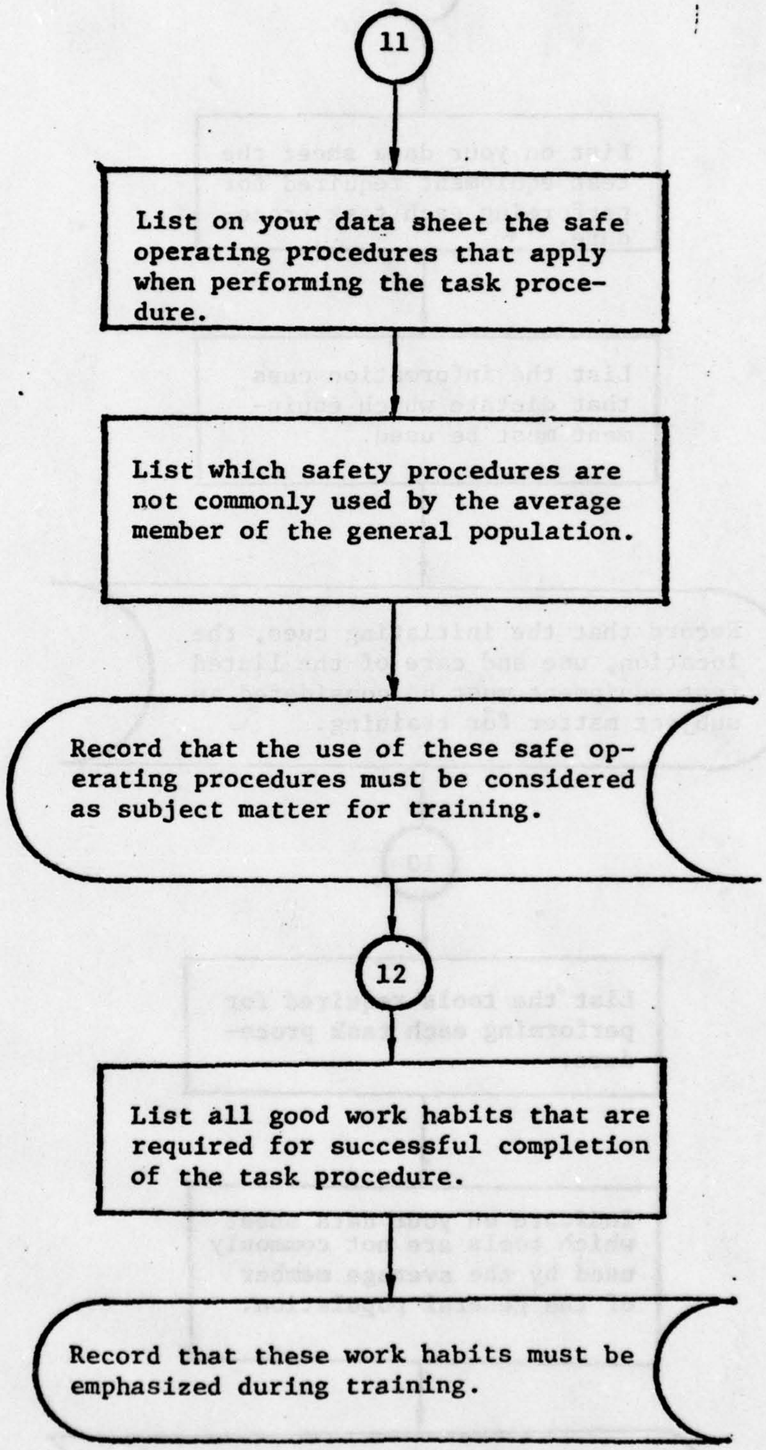
4. What the source of the problem may be. Does the evaluation of the information indicating a malfunction require a knowledge of:

   a. How the equipment functionally operates? and/or
   b. Why the equipment theoretically operates?

8


8
Where is the information obtained?
From memory?
If yes, record on your data sheet that this information must be considered as subject matter for training.
From a special reference document?
If yes, record on your data sheet that the location and use of the reference documents must be considered as subject matter for training.
From the use of a test instrument?
If yes, record on your data sheet that the use and care of the test equipment must be considered as subject matter for job training.
9


9
List on your data sheet the test equipment required for performing each task procedure.
List the information cues that dictate which equipment must be used.
Record that the initiating cues, the location, use and care of the listed test equipment must be considered as subject matter for training.
10
List the tools required for performing each task procedure.
Indicate on your data sheet which tools are not commonly used by the average member of the general population.
Record that use and care of these tools must be considered as subject matter for training.
11


11
List on your data sheet the safe operating procedures that apply when performing the task procedure.
List which safety procedures are not commonly used by the average member of the general population.
Record that the use of these safe operating procedures must be considered as subject matter for training.
12
List all good work habits that are required for successful completion of the task procedure.
Record that these work habits must be emphasized during training.

Category 4, Safe Operating Procedures, and Category 5, General Work Habits were defined in terms of specific behavoir statements (See Appendix B). Safe operating procedures and good work habits were defined as behaviors that were required to be performed whenever appropriate. The application of these behaviors were considered to reflect a general positive and responsible attitude toward the maintenance job. These were not individual behaviors that could be meaningfully counted in an analysis of maintenance task procedures. Rather, they were noted as being necessary to the overall success of the job.

Category 7, Recognition of Cues, actually referred to a basic assumption that there were normal and non-normal operating conditions. This concept was considered to underlie preventative maintenance, periodic checks and troubleshooting in the sense that the sooner non-normal functioning could be predicted or detected the better. Being alert to signals of operational functioning and malfunctioning was considered a general work habit, but it was singled out as a behavior that should be taught rather than just an attitude.

Job Performance Aids, Category 6, referred to any kind of formal job assistance that would be available to the technician on the job. Included were reference manuals, charts, troubleshooting guides, coded schematic diagrams, etc.

One special skill that included the use of subordinate skills was malfunction diagnosis. Several approaches to troubleshooting had been proposed over the years including the use of job performance aids. The analysis here resulted in this skill being described as a problem solving exercise. An outline is presented in Appendix B to represent a general approach to describing the diagnostic process.

As the use of the analysis process model proceded, it became difficult to differentiate between a skill and a knowledge, so the distinction was essentially dropped. As the TAPM questions were asked, specific behavioral statements were prepared as responses and given a code desig-

nation. Nine categories of statements resulted from the use of the model:

B-1 Electronic Concepts
B-2 Tools
B-3 Hardware
B-4 Test Equipment
B-5 Mechanical Skills
B-6 Mathematical Concepts
B-7 Electronic Components
B-8 Electronic Circuits
B-9 General Electrical and Mechanical Equipment

These category titles were choosen to indicate the content focus of a set of skill and knowledge statements. The specific statements for each category are presented as Appendix B.

The task analytical process model was applied quantitatively to 18 of the 21 IBCC and IPAR tasks. Across these eighteen tasks, the analysis resulted in the identification of 11,507 applications of a skilled behavior or the recall and use of special information. The summary of this analysis is presented in Table 5. The nine skill and knowledge categories are listed in the left column. The total application of skills and knowledge from each category is listed in the right hand column. Table 5 presents the number of times during the analysis of each task that skills and knowledge in each of the nine categories were counted as being applied in the performance of the task procedures. Skills and knowledge dealing with electronic components were found to be applied 4,876 times, more than any other category. The use of electronic concepts was found to occur 3,074 times.

The most complex, in terms of the use of skills and knowledge was task 7, which required twice as many applications as any other task. A detailed breakout of this summary is presented in Appendix C.

Table 5

Summary of the Detailed Skills and Knowledge Results from the Use of the Task Analytical Process Model

Skill Knowledges Categories	Tasks 1	2	3	4	5	6	7	8	9
Total each task	858	190	172	237	1060	1118	2820	370	420
B-1 Electronic Concepts	87	26	29	37	221	284	960	63	79
B-2 Tools	112	8	17	27	32	21	17	31	31
B-3 Hardware	3	12	14	32	-	-	-	-	8
B-4 Test Equipment	93	30	1	-	4	182	556	30	63
B-5 Mechanical Skills	48	4	17	-	31	33	22	20	73
B-6 Mathematical Concepts	3	-	-	-	-	82	291	19	38
B-7 Electronic Components	497	107	77	138	770	514	961	201	108
B-8 Electronic Circuits	3	3	3	3	2	2	13	6	3
B-9 Electronic Circuits	12	-	14	-	-	-	-	-	17

Table 5 (cont.)

	Tasks									Total Across Tasks
	10	11	12	13	14	15	16	17	18	
	503	684	55	116	97	104	336	1046	1318	11,507
B-1	96	209	6	27	20	27	123	372	408	3,074
B-2	28	8	6	14	13	14	38	12	33	462
B-3	-	6	14	20	28	16	13	11	25	202
B-4	101	88	-	4	-	4	28	170	201	1,555
B-5	9	12	9	17	20	17	5	16	17	370
B-6	74	40	3	2	2	2	2	64	142	764
B-7	189	292	10	27	10	18	107	381	469	4,876
B-8	6	29	-	-	-	-	20	20	20	133
B-9	-	-	7	5	4	6	-	3	3	71

Three additional tasks were selected and analyzed because of their unique skills and knowledge requirements. Task 19, Troubleshoot the Information Co-ordination Central, was selected because it dealt with special digital technology skills and knowledge that were required in the 24H MOS. The rationale for selecting this special task was that fundamental digital technology skills and knowledge are proper subject matter for basic electronics training and therefore the task should be analyzed to identify skills and knowledge that could differentiate between MOS's.

The other tasks, Task 20, Perform Troubleshooting of the Antenna Control Circuits of the Improved Range Only Radar, and Task 21, Perform Troubleshooting of the Improved Pulse Acquisition Radar, were selected for unique requirements of knowledge and skills with antenna control circuits (Task 20) and Radar Transmitter and receiver operation (Task 21).

These three tasks served as examples where special basic skills may be needed in one MOS but not in related MOS's.

Electronic Maintenance Job Fundamentals Questionnaire

The results of the task element analysis led to the preparation of statements describing fundamental skills and knowledge that were determined to logically underlie electronic maintenance job performance. As a check of the validity of the results of the logical analysis, these statements were organized into the form of a questionnaire, which was then administered to technicians from the 24E, 24H, and 24J MOS's.

The Electronic Maintenance Job Description Survey consisted of a total of 556 items dealing with work behaviors. The complete questionnaire is presented in Appendix D. Thirty eight of the items described general work habits and safety procedures. The remaining 518 items were skill and knowledge statements. The skill and knowledge items were clustered in 36 topic groups (see Table 6). It was decided to use the same form of the questionnaire for all three MOS's. This added a validity check to the data. Some items were MOS specific and the rationale

for their use was that only technicians with the MOS's should respond to these items. This provided a validity check for the questionnaire results in that technicians with another MOS should not respond to other MOS specific items.

The questionnaire was divided into three sections. The first was a background information section. Only part of this information was actually used in the analysis because of the small number of responses to some items. The second section asked for ratings of the importance of each item to overall job success. The third section asked the technician to indicate whether or not he had performed the activity described.

The questionnaire was first given an administrative tryout with only a few subsequent modifications being made. The validation tryout was administered as follows:

	Ft. Bliss	Redstone	Total
24E	20		20
24H	8	7	15
24J		15	15
			50

A high degree of agreement was found between the results of the task element analysis and the responses to the Job Description Survey. Table 6 presents the summary of the survey responses. There were a total of 518 skills and knowledge items in the survey. Samples of technicians in each MOS indicated whether they performed the behavior in each statement. A total of 454 of the items were reported as being performed by more than 50% of the 24E mechanics. This was 88% of all items. Totals of 422 (81%) and 474 (92%) items were performed by over 50% of the 24H and 24J, respectively. Because the same survey questionnaire was used across these three MOS's, some items were not applicable to all MOS's. Therefore, 100% affirmative responses was not expected within any MOS.

Looking at the results for individual item clusters in Table 6 revealed more differences between the 24H MOS and the other two, which again was expected. The 24E and 24J technicians are responsible for a larger number of the same pieces of equipment. Almost all items derived from the logical task element analysis within each MOS were reported as being performed by 90% or more of the technicians (for the items relevant to their MOS). The results in terms of percent performing each item is presented in Appendix E.

The question of whether a technician should have understanding of the "why an electronic component or circuit works at the electron level" question has had its proponents and opponents over the years. The task element analysis indicated that a technician needs to know <u>how</u> a circuit, component or chassis operates, but does not need to know <u>why</u> they function at the electron level. However, individual technicians have cited special problem situations where the best available solution essentially required design theory knowledge. It also became apparent in this project that the more experience and the more education a technician had, the more he felt that the electron theory knowledge was needed for successful maintenance performance.

Accordingly, the questionnaire included statements concerning the use of both "how it operates" and "why it functions" kinds of knowledge. Items TH19-1 through TH19-26 presented these kinds of questions. Generally, a higher percent of technicians answer that they refer to or apply information about how something works than they do why something works. (See Appendix E).

The information presented in Appendix E can be used to establish priorities for selecting content for maintenance training courses. For example some material would be given lower priority with reference to actual application on the job. Table 7 presents an example of skills and knowledge that were reported as being seldomly applied by the 24E technicians.

Table 6

Electronic Maintenance

Job Description Survey

Skills and Knowledge Clusters

Cluster Code	Cluster Topic	Total # of items	# of items over 50% 24E	24H	24J
B1	Electronic terms	22	21	19	22
B2	Measurement units	7	6	7	7
B3	Electrical circuits	2	2	2	2
B4	Vacuum tube circuits	12	12	12	12
B5	Solid state circuits	11	10	11	7
B6	Microwave circuits	8	8	4	8
B7	Electrical items	20	20	16	20
B8	Test equipment	15	12	9	15
B9	High frequency console	12	1	12	12
T10	Tools	22	18	19	20
M11	Mechanical items	22	22	15	22
MC12	Mathematical and measurement concepts	43	28	36	32
SC13	Electronic symbols and designations	11	11	11	11
SC14	Schematic symbols	140	121	106	120
SC15	Schematic reference designations	46	46	45	46
B16	General Electronic maintenance procedures	13	12	13	13
I17	Information use	9	9	9	9
Th18	Theory Use	26	26	17	26
EE19	Transmitters	7	7	0	7
EE20	Receivers	7	7	0	7
EE21	Electric motors	7	5	7	5
EC22	Cathode ray tubes	4	4	3	4
EC23	Vacuum tubes	3	3	3	3
EC24	Resistors	4	4	4	4

Cluster Code	Cluster Topic	Total # of items	# of items over 50% 24E	24H	24J
EC25	Capacitors	4	3	4	4
EC26	Diodes	3	3	3	3
EC27	Transformers	3	3	3	3
EC28	Relays	3	3	3	3
EC29	Circuit cards	4	3	3	3
EC30	Switches	3	3	3	3
EC31	Fuses	3	3	3	3
EC32	Lamps	3	3	3	3
EC33	Connectors	4	4	4	4
EC34	Power cables	5	3	5	3
EC35	Data cables	5	3	3	3
EC36	Coaxial cables	5	5	5	5
	Total	518	454	422	474
			(88%)	(81%)	(92%)

Table 7

Skills and Knowledge Reported Used by Less Than 50% of The 24E Technicians

Using or referring to the following:

Bandpass	40%	Rectangle	35%
Henries	40	Right triangle	35
N nano	50	Nano-seconds	30
Square root	25	Binary numbers	45
Square of a number	30	Octal numbers	25
Algebra equations	15	Hexidecimal	25
Radius of a circle	50	Boolean algebra	30
Minutes in a degree	30	Logic diagrams	50
Perimeter of a circle	40	Truth tables	35
Intersect	50	Parallax theory	55
Rank order	40		

Performing the following:

Adjust electric motors	45%	Repair circuit cards	20%
Select capacitors by color code	45	Fabricate power cables	20
Remove/replace electric motors	40	Repair data cables	35
Repairing adder circuits	40	Fabricate data cables	15

Using the following:

Stop watch	50%	Thickness gauge	40%
High frequency console	10	Dial indicators	50
Rulers	50	Card extractors	40

SECTION IV

NON-FUNCTIONALLY RELATED EVALUATION CRITERIA

In the introduction of this report it was mentioned that field commanders and supervisors possibly had a different set from which they evaluate maintenance competency. This perceptual set was laced with beliefs about how a "good" technician should behave on the job. On the negative side, the set also included beliefs about the undesirable behaviors of the inadequate technician. One such positive belief was that the good technician will do what he has to do to keep the system on the air. Also, he will take the initiative and make the decision to perform unauthorized maintenance tasks. He will work long hours, staying on the job until the system is up again. The good technician also looks good; is neat, keeps his work area neat and clean, is careful in his work, etc.

One phase of this research project was to identify non-functionally related job performance evaluation criteria and determine the extent of the relationship between ratings with these criteria and actual task element performance. The non-functionally related evaluation criteria were identified in a series of interviews with officer, warrant officer, non-commissioned officer and enlisted personnel. The interview questions are presented in Appendix F (pages F1 & F2). These questions were used to guide the interview only. The purpose of asking questions was to stimulate the thinking of those interviewed. The desired result was an extensive list of evaluation or comparative statements reflecting perceived differences between "good" and "poor" electronic maintenance technicians.

Interviews were conducted at Ft. Bliss and at Redstone Arsenal. The grades of the interviewees varied from E-4 to E-5. All supervisors and commanders interviewed had had field experience, some with several years on-site.

Three kinds of information were obtained. First, evaluative and comparative information was obtained for the purpose of constructing

evaluation criteria statements. Second, descriptions of field units with good as well as poor maintenance programs were recorded. And third, information reflecting technician and supervisors beliefs about the school training programs was volunteered.

The interviews were successful in that the desired information was obtained. There was a high degree of consistency in the responses from over 30 interviewees. The most agreement was found with the statement that new school graduates are almost always not qualified to perform maintenance. The consensus was that it generally takes from one to five months to qualify the new school graduates so they can be given responsibility for maintenance within a unit. Some individuals never become qualified, always working in an assistant role.

The interview results were used to construct a questionnaire with 51 items (Appendix F, pages F3 to F7). Many of the statements reflect the use of good work habits and safe operating procedures. Other items are statements of attitudes toward work and especially toward maintenance. The remaining items can be classified as behaviors that represent personality characteristics.

The questionnaire was then administered to a total of 56 supervisors and commanders at Ft. Bliss and Redstone Arsenal. For this administration the questionnaire called for an indication of how important, on a scale of 0 to 10, each item was for use as an evaluation criterion. The purpose of the administration was to obtain data, to be used for selecting the most important evaluation criteria. Twenty items rated as the most important by the 56 supervisors and commanders were used to construct a shorter evaluation form. The short form with the assessment scale is included in Appendix F (F-8-F-10).

A summary of the results of the administration of the 51 item questionnaire to the 56 supervisors and commanders is presented in Table 8.

Table 8

Mean Importance Ratings on Evaluation Criteria Statements

Statement Number */	Fort Bliss			Redstone Arsenal		
	NCO	Warrant Officer's	Company Grade Officer's	NCO	Warrant Officer's	Company Grade Officer's
1.	9.6	9.8	9.1	7.8	7.8	8.0
2.	9.6	7.8	7.0	8.1	7.8	7.6
3.	9.0	8.2	9.0	8.1	7.6	8.2
4.	8.1	6.6	5.7	7.7	6.5	8.2
5.	9.0	7.7	7.0	8.1	6.8	6.6
6.	8.9	8.0	7.8	8.7	7.6	8.8
7.	8.6	8.5	7.5	8.2	7.1	7.2
8.	8.7	8.2	6.7	8.1	7.3	8.2
9.	8.9	8.6	6.7	8.2	7.8	7.0
10.	9.7	8.2	8.2	8.7	7.1	8.0
11.	7.5	8.5	7.0	8.7	8.0	8.2
12.	9.5	8.8	7.8	8.9	8.3	8.2
13.	7.5	7.8	6.7	7.8	8.0	6.0
14.	9.5	9.6	7.7	9.0	8.6	7.8
15.	7.5	7.5	6.7	7.4	6.6	4.6
16.	9.2	9.2	8.8	8.7	7.8	7.0
17.	8.5	7.6	6.7	8.6	7.5	7.8

*/ See Appendix F (pages F-3-F-7) for statements

Table 8 (cont.)

Statement Number	Fort Bliss			Redstone Arsenal		
	NCO	Warrant Officer's	Company Grade Officer's	NCO	Warrant Officer's	Company Grade Officer's
18.	8.3	7.7	6.0	8.1	6.8	7.6
19.	9.1	8.0	7.0	7.6	6.7	8.2
20.	9.8	8.5	8.3	8.5	7.8	7.8
21.	9.5	8.1	7.4	8.6	8.0	6.4
22.	9.9	9.4	8.3	9.2	8.5	8.8
23.	9.0	8.1	7.9	8.5	8.8	8.4
24.	7.9	7.9	4.9	6.8	5.8	2.4
25.	8.1	7.2	5.7	8.2	7.3	7.4
26.	9.3	9.6	8.4	9.2	8.8	8.4
27.	8.7	9.9	9.1	8.6	8.5	7.8
28.	9.1	9.5	8.3	8.8	8.5	7.0
29.	8.8	9.4	8.7	8.5	8.7	8.2
30.	8.5	7.7	5.1	7.5	7.7	6.0
31.	6.6	5.2	7.0	7.5	7.7	3.6
32.	9.4	8.4	8.9	9.1	7.5	7.6
33.	9.7	8.9	8.6	9.1	8.3	9.2
34.	8.9	8.2	7.6	8.5	7.7	5.8

Table 8 (cont.)

Statement Number	Fort Bliss			Redstone Arsenal		
	NCO	Warrant Officer's	Company Grade Officer's	NCO	Warrant Officer's	Company Grade Officer's
35.	8.6	8.4	8.3	8.2	8.2	7.6
36.	8.6	8.9	7.6	8.8	7.7	8.6
37.	9.1	9.1	7.6	8.8	8.2	8.8
38.	9.0	9.2	8.4	8.9	9.2	8.2
39.	8.0	7.7	7.6	8.5	7.5	6.6
40.	8.3	7.7	5.7	8.1	7.2	6.2
41.	8.9	8.9	6.3	8.2	7.3	5.4
42.	9.0	8.2	7.4	8.8	7.5	8.0
43.	9.4	9.5	7.1	8.5	8.0	7.8
44.	9.0	8.5	7.7	8.4	7.3	5.8
45.	7.2	4.4	2.7	6.4	4.3	1.2
46.	8.7	8.0	6.6	7.3	6.8	4.2
47.	8.7	7.0	7.0	9.0	6.8	8.8
48.	9.2	8.4	8.4	8.6	8.5	8.0
49.	9.2	8.4	7.9	8.6	6.5	7.0
50.	9.1	8.5	8.1	8.4	7.3	8.4
51.	9.4	8.6	7.7	8.5	8.8	7.8

The results were broken out by administration location and by rank groups. The location data may be interpreted as the relevance of the statements for evaluating mechanics (Ft. Bliss data) and repairmen (Redstone data). The difference in results for rank groups can be interpreted as indicating different points of view. The NCO's and warrants, being technicians themselves, would be expected to be more concerned with those statements that would promote quality work as well as job responsibility. The company grade officers would be expected to rate items higher than would be relevant to management problems and issues.

The interpretation of the results tended to confirm the above hypotheses. Although there was no significant overall differences between Ft. Bliss and Redstone Arsenal responses, a few items reflecting MOS specific responsibilities were rated differently. For example, item 1, "Quickly and correctly identifies malfunction causes," was rated at 9.7 by Ft. Bliss NCO's and WO's, but only 7.8 by Redstone NCO's and WO's. The 24E is responsible for system troubleshooting which has command pressure to be done as quickly as possible, whereas the 24H's and 24J's working in a support unit do not generally have the same pressures. Other differences between Fort Bliss and Redstone responses were:

Item #		F.B.	R.A.
19	Emotionally mature	8.6	7.1
43	Preventive maintenance	9.5	8.3
46	Recognizes unusual conditions	8.4	7.0
49	Keeps work clean	8.8	7.6

The company grade officers tended to rate the following kinds of items higher than other items:

Item #	
1	Quickly identifies malfunction
2	Clear understanding of job objectives
3	Performs mechanical tasks correctly
7	Meets time schedules

Item #	
10	Performs all work needed to be done
16	Does not make wild guesses
20	Has high level of persistence
22	Is reliable
27	Logical in troubleshooting
32	Is honest
33	Keeps supervisor informed

NCO's and WO's tended to rate maintenance related items higher than did officers.

Item #	
11	Replaces all hardware
34	Plans the job
36	Uses correct references
40	Helps others with maintenance problems
41	High level of work endurance
43	Performs all preventive maintenance
46	Recognizes unusual conditions

Only a few of the items were given relatively low rating. Some of the items with lower ratings were:

Item #		
15	Interacts with little or no conflict	6.8
24	He is well educated	6.0
31	Does not take short cuts	6.1
45	Has a wide range of interests	3.4

In summary, it appeared that there are non-functionally related criteria that supervisors and managers would use for rating technicians.

SECTION V

SKILLS AND KNOWLEDGE VALIDATION

The task analytical process model was validated using a performance oriented test constructed from the 551 item job description survey questionnaire. The test consisted of 66 items divided into 9 sections, each section calling for the performance of different fundamental electronic activities. Some items were knowledge oriented and others skill oriented. A copy of the test form is included in Appendix G. The test instructions and test layout is also included in Appendix G. An outline of the test by section is presented in Table 9.

Table 9

Performance Test Outline

Test Section Number	Evaluation Categories	# of items
1	Component Location on Schematic Diagram	20
2	Definition of Electronic Terms	20
3	Read Color Code of Resistors	2
4	Conversion of Measurement Units	5
5	Continuity Check - PSM-6	8
6	Component Check - DVM	8
7	Circuit Check - TS-505	1
8	Circuit Check - Oscilloscope	1
9	Troubleshoot Chassis	1

The performance test was given an administrative tryout using 20 24E, 5 24H, and 5 24J technicians at Ft. Bliss. A few administrative changes were made before the conduct of the validation testing. The final form of the test is included in Appendix G. Testing was conducted at three locations: 3rd Battalion, 68th Air Defense Artillery, Homestead Air

Force Base, FL; 1st Battalion, 65th Air Defense Artillery, Boca Chica Naval Air Station, Key West, FL; and Redstone Arsenal, Huntsville, AL. A total of 29 24E's, 16 24H's, and 15 24J's were tested. Each technician was rated by two or three supervisors. For those who had taken an MOS test, the scores of their last test was obtained. The total experience in electronic maintenance was also recorded for each man tested. The average experience for the technicians is presented in Table 10 and the rank data in Table 11.

Table 10

Experience Data for Technicians Who Took Job Performance Test

MOS	Mean	Range
24E	31 months	4-145 months
24H	32	2-100
24J	40	10-100

Table 11

Rank Break-out for Technicians Who Took Job Performance Test

	Rank					
MOS	E-3	E-4	E-5	E-6	E-7	TOTAL
24E	11	4	7	5	1	28*
24H	2	5	5	4		16
24J		5	7	3		15

*One additional technician had been reduced in grade to E-1.

Because the test was made up of various numbers of items within each section, the test performance of each technician was normalized by using

the percent correct score within each section. The percent correct scores within the section were also weighted using empirically derived weights. A sample of thirty-five experienced technicians were asked to rate the importance of each type of maintenance skill or knowledge represented in each section. They were asked to use a rating scale of 1 to 10. The ratings were averaged across the thirty-five raters. The section on identifying resistance value by reading color codes was given the lowest rating. This rating value was divided into the other values to obtain a relative weight for each item. The derived weights were:

Section Number	Evaluation Categories	Item Weight
1	Component Location on Schematic Diagram	1.84
2	Definition of Electronic Terms	1.36
3	Read Color Code of Resistors	1.00
4	Conversion of Measurement Units	1.12
5	Continuity Checks - PSM-6	1.50
6	Component Check - DVM	1.58
7	Circuit Check - TS-505	1.42
8	Circuit Check - Oscilloscope	1.68
9	Troubleshoot Chassis	1.82

For analysis purposes the Evaluation Categories on schematic reading were combined, as were the tests on continuity and component checks, which involved the use of the digital voltmeter. The summary of the test results are present in Tables 12,13, and 14.

Table 12

Test Performance Results for

24E Improved HAWK Mechanic

Sample Size	Grade	Average Experience (months)	Average Performance Per Test Section (Percent Correct) 1	2	3	4	5	6	7	8	9	Average Rating	Average Weighted Test Score
12	3	6	86	71	13	40	89	49	50	58	17	58	7.23
4	4	14	83	70	0	45	94	75	25	100	0	66	7.61
7	5	37	86	69	15	34	98	48	57	43	43	71	7.50
6	6-7	91	88	83	25	60	94	69	67	67	17	69	8.56
	TOTAL		86	73	14	44	93	56	52	62	21		7.63

Table 13

Test Performance for 24H

Improved HAWK Fire Control Repairman

Sample Size	Grade	Average Experience (months)	Average Performance Per Test Section (Percent Correct) 1	2	3	4	5	6	7	8	9	Average Rating	Average Weighted Test Score
2	3	5	83	73	25	70	100	56	100	100	50	58	9.94
5	4	11	93	89	40	80	100	75	50	80	20	63	9.32
5	5	28	89	82	40	80	98	78	40	100	40	54	9.74
4	6	54	85	84	38	65	88	72	75	50	50	71	9.09
	TOTAL		88	83	38	75	96	73	63	81	38		9.50

Table 14

Test Performance for 24J

Improved HAWK Pulse Radar Repairman

Sample Size	Grade	Average Experience (months)	Average Performance Per Test Section (Percent Correct) 1	2	3	4	5	6	7	8	9	Average Rating	Average Weighted Test Score
5	4	18	91	82	50	64	78	75	60	40	9	55	7.90
7	5	40	96	83	93	63	100	77	86	57	43	57	10.20
3	6	77	94	90	67	67	92	75	67	33	67	70	10.50
	TOTAL		94	84	73	64	91	76	73	47	33		9.32

Individual technician performance data is presented in Appendix H.

The results of the validation testing confirmed that the task analytical process model produced a valid set of fundamental skills and knowledge for the electronic maintenance MOS's studied. The derived set of skills and knowledge covered two kinds of maintenance jobs - the mechanic and the repairman. The mechanic job required system rather than electronic chassis troubleshooting. The repairman was primarily concern-

ed with chassis troubleshooting. This job requirement difference was reflected in the test scores. For example, 37 percent of the repairmen successfully completed the troubleshooting task, whereas only 21 percent of the mechanics were successful.

The 24E mechanic very seldom reported working with resistors. The 24J repairman reported working with them almost on a daily basis. Test scores sharply reflected this difference in job experience. The 24E's scored 14%, 24H's scored 38%, and 24J's scored 73%. Other job differences reflected on the test were converting measurement readings from one kind of scale to another. Repairmen do this much more often than mechanics and the test scores reflect this: 24E 44%; 24H 75%; and 24J 64%. The repairmen also use a digital voltmeter in the High Frequency Console, whereas the mechanic very seldom use a DVM. Again test score differences reflect this: 24E 56%; 24H 73%; 24J 76%.

These job requirement differences account for most of the differences in total test scores between the mechanic and technician MOS's. This was demonstrated by comparing the two sets of scores:

	24E	24H	24J	Perfect Score
Total Test	7.63 (57%)	9.50 (71%)	9.32 (70%)	13.32
Common Job Elements	5.75 (61%)	6.44 (69%)	6.06 (65%)	9.38

A perfect performance total test score for each set of scores is indicated in the last column. The percent the scores are of the total possible are indicated in parentheses.

Early in the project rank and experience were considered as a means for differentiating skill level of technicians. Coefficients of correlation were run for rank and experience with test scores and ratings. For the 24E mechanics, correlations significant at P = .10 were found between test scores with rank (r = .31) and experience (r = .33). Similar coefficients were found with the 24J data, but the degrees of

freedom were lower so the rank figure was not significant (with rank r = 31; experience r = .42, p = .10). The coefficients for the 24H were not significant.

Correlations of test scores with the external evaluation criteria of supervisory ratings and MOS test scores were also run. None of these coefficients were significant. Two explanations of this lack of correlation between test performance and supervisory ratings can be offered. The first deals with the content of the test vs. the content of job performance. The test included only electronic fundamentals and did not deal with system specific behaviors and knowledge. To the degree that performance on system specific activities influences a supervisor's ratings, the influence of performance on electronic fundamentals may be reduced. That is, a technician who performs other aspects of the job much better than he performs on fundamental tasks may be rated higher than in the reverse situation.

A second explanation would be that ratings may be based on general behavior (personality) characteristics to a greater extent than on actual job performance. If this were the case, ratings would not correlate with experience or rank either. This in fact was the case. There were no significant correlations of ratings with experience for all MOS's and none with rank for the 24H and 24J. The correlation of rating with rank was significant at p = .10 for the 24Es.

SECTION VI
DEVELOPMENT OF GUIDELINES FOR COURSE DEVELOPERS

Introduction

Task analysis at the skills and knowledge level of abstraction is still somewhat of an art-form. Decisions must be made that currently can best be made by someone with a combination of training and experiences in educational technology and the job content. This project was the first step in the attempt to move the analytical process from being an art form towards being a scientific process. This first step was empirically derived and appears to have successfully moved the process towards the science end of the continum in that fewer assumptions have to be made about the job performance activities than is now the case in course development. A copy of the Guidelines is attached as Appendix I.

As the model was evolved, two assumptions had to be met. First, the MOS to be analyzed at the skill and knowledge level had to be well documented. This meant that the FM's, TM's, and AR's relevant to the maintenance job had to be available, complete, accurate, and valid. This was necessary since the first set of procedures of the process identified all maintenance tasks that were required to be performed. Being complete and valid meant that the list of task elements were sufficient for describing all activities necessary for successful task completion. If the task elements had not been validated by observing a technician in that MOS carry out the task, or by doing the task yourself, the model was designed to provide for this necessary step.

The second assumption was that the analytical process had to be carried out by someone with some minimum level of job proficiency and field experience (yet to be established). In analyzing the task elements, certain decisions had to be made that were best made at this time by a job content expert. A layman or even an instructional development expert could not make these decisions.

The Task Analytical Process Model procedures were evolved as three sets of activities. First the process of task identification and selection was dealt with. Next the task element analytical procedures were developed. And finally the process for validating the skills and knowledge was designed. One staff member had over twenty years of electronic maintenance experience in addition to educational background and experience in instructional design technology. He served as the primary analytical tool for driving the TAPM procedures. Once general approaches to each aspect of the Model were agreed upon this staff SME began working through the details. A continuing interrogative interchange was set up between the SME and project director. The project director essentially acted as a naive observer who asked the questions "What did you do?", "Why did you do that?", and "How did you know to do that?".

Task Identification Matrix

The development of the TIM evolved from the requirement to develop a process for identifying all tasks required for performing the job of a given electronic maintenance MOS. From this pool of all tasks, representative, critical tasks were selected for detailed analysis to derive common underlying skills and knowledge.

It was determined that all maintenance tasks involve some system equipment. The first effort was then to develop a process of identifying and classifying equipment. The Maintenance Allocation Charts and Parts Manuals were used for this purpose. By cross referencing these documents, a list of equipment was prepared that could be used to categorize all maintenance activities. It was next determined that a finite number of maintenance tasks are authorized to be performed in the MOS. These twelve tasks were subsequently grouped under four categories: Periodic Checks; Preventive Maintenance; Malfunction Diagnosis; and Corrective Maintenance. Feedback from technicians and their supervisors indicated that it was at this level that technicians become certified as qualified to perform the maintenance duty.

The criteria for selecting tasks for analysis were embodied in a definition of task criticality. A task was decided to be critical if (1) it was performed by a majority of the technicians, (2) was performed often on a piece of equipment that, (3) failed at a high rate, (4) resulted in the IHAWK System being classified in a non-ready status, and (5) if it was similar to other tasks.

The percent performing and frequency of performance data was obtained by administering the TIM to a sample of job incumbents for each MOS. This process was used rather than using the MOD-B report because of the in-consistency in the level and focus of the MOD-B questions. The frequency of failure data came from actual failure reports prepared at Redstone Arsenal. The readiness status data was obtained from the Equipment Serviceability Criteria (ESC) in TM-9-1425-525.

Those tasks that were classified as critical according to the above definition were reviewed by the staff SME for similarity of skill and knowledge requirements. The 18 most representative tasks were then selected for detailed analysis. This selection process was based on the SME's expert knowledge of the job requirements.

The next essential step was to determine whether the description of each of the selected tasks was complete and valid. This was accomplished by arranging for the SME to observe each task as it was performed in an actual job setting. The procedures for each task as presented in the TM were used as an observation check list. As a procedural step (task element) was performed, it was checked off by the SME. If the technicians carried out an activity not included in the list, a note was made and he was asked why he did it. Also where steps were omitted reasons were also obtained. A combination of this information and the staff SME's knowledge produced complete and valid sets of task elements.

Process Model Procedures

The general approach that was agreed upon for analyzing the task elements was to describe how and why each element was performed. The TAPM flow chart items were prepared from the answer to the questions the pro-

ject director asked of the staff SME.

First a list of individual behavioral statements were prepared. Where it made logical sense, the items were grouped into categories of behavioral content. Each category was given an alpha-numeric code and each statement with a category was numbered sequentially as it appeared in the analysis. The same behavioral activity was found to be performed as part of several task elements. Such an activity was given only one code number, but its numerous replications were noted to reflect the skill or knowledge density of application in the job.

After each of the 18 representative tasks were analyzed, the remaining tasks as indicated by the TIM administration were reviewed. This was for the purpose of determining whether any fundamental skills had been omitted for any MOS. It was determined that the 24H performed some tasks that required digital technology skills and knowledge. As a result three additional tasks were analyzed to identify the specific skills and knowledge in this area.

Validation of Skills and Knowledge

For this research effort two levels of validation were used. First it was assumed that if the logical task element analysis was valid, a majority of job incumbents should report that they apply the special skills and knowledge derived for the MOS. To test this assumption a job description questionnaire was prepared from the lists of skills and knowledge. This questionnaire was then administered to a sample of technicians with the subject MOS.

The second level of validation was based upon the assumption that if a technician reports he applies certain skills and knowledge on the job, he should be able to demonstrate this on a performance test. Therefore a performance test was constructed based on the responses to the questionnaire. This test was administered to a different sample of technicians with the MOS.

In both cases, the results indicated that the previous step produced valid products. It was subsequently decided that if a validation step is necessary, the use of a job description questionnaire would be sufficient.

The list of behavioral statements produced from the task element analysis represent a pool of special skills and knowledge that must be acquired by an individual before he can perform successfully as an electronic technician. Where and how they are acquired are decisions that must be made subsequent to the application of the Task Analytical Process Model.

SECTION VII

SUMMARY AND CONCLUSIONS

The question of what fundamental skills and knowledge should be the subject matter of basic electronic training courses has been dealt with over more than two decades. The Basic Electronic Skills and Knowledge project addressed the problem of developing a process for generating information that can be used to make this decision. It was determined that the approach should be focused on actual job activities rather than on current training content.

The Task Analytical Process Model that was developed was an evolutionary process. The documented analytical procedures emerged as the project was carried out. First a set of procedures was developed to identify tasks performed in an electronic maintenance MOS. This produced a form called the Task Identification Matrix (TIM). This consisted of a list of equipment and list of maintenance tasks. A TIM was developed for two major pieces of Improved HAWK equipment - The Battery Control Central (IBCC) and the Pulse Acquisition Radar (IPAR). Each TIM was administered with a set of questions to technicians responsible for these equipment items. The purpose was to focus in on critical tasks that were to be used for developing the detailed task analysis process. Two other criteria were also identified and used in classifying the criticality of task. Three MOS's were responsible for this equipment - 24E; 24H; 24J.

A total of 18 tasks were initially selected for developing the analytical process. These 18 tasks were selected because they were representative of 267 tasks for the two pieces of equipment and three MOS's. The staff SME proceeded to analyze these 18 tasks. The process used was documented and described in terms of procedural steps. The analysis produced a total of 518 skill and knowledge content items. These items reflected the application of related skills and knowledge a total of 11507 times across the 18 tasks. The most often applied skills and knowledge

were classified as electronic component content. Second was the application of electronic concept skills and knowledge. The most infrequently applied skills and knowledge categories was that for electronic circuits and electronic equipment (such as motors).

The results of the analytical process were used to construct a questionnaire about the application of special skills and knowledge that were of a fundamental (basic) nature. This was administered to a total of fifty technicians (20 24E's, 15 each 24H and 24J) for the purpose of determining the validity of the analytical process. The results were that about 90 percent of the items were reported being performed by a majority of the technicians. It was concluded that the analytical process produced a valid set of basic skills and knowledge items.

As a further validity check, a performance test was constructed which reflected the responses to the questionnaire. This test was administered to 59 technicians (29 24E's, 15 each 24H and 24J). Technicians were able to demonstrate proficiency on those items common to their MOS. Again it was concluded that the analytical process produced valid skill and knowledge content items.

During the conduct of the several phases of this project information was provided by technicians that was of interest for training and management personnel. For example: Repairmen, trained at the Ordinance school, Redstone Arsenal, reported that many times in the field they had been called to assist in or to conduct system troubleshooting. They reported frustration because they could not perform well, not having had training on the entire system operation. Many expressed a desire to have been given this training while still in school. Both repairmen and mechanics reported some problem with having to learn how to operate test equipment once they got to their job assignment. They report not having seen the actual job test equipment while in school.

Another reported practice was that sometimes technicians must perform maintenance tasks that are not authorized for their MOS. This was reported being due to management pressure to return equipment to the operational status as soon as possible. Along this line it was also often reported that the difference between a unit with good maintenance as opposed to poor maintenance was the strength of the maintenance managers. In the good units, managers insist that all required maintenance tasks be performed and carried out completely. Managers in these units also promote the attitutdes of responsibility and professionalism as far as maintenance technology is concerned.

A second part of this research project addressed the issue of personnel evaluation. It had been hypothesized that maintenance supervisors and commanders used non-functionally related criteria in rating a technician as competent (qualified). During a series of open-ended interviews with supervisors and commanders a list of descriptive criteria were generated that were used to differentiate good and poor technicians.

This list was used to construct a questionnaire that was administered to another sample of maintenance supervisors and commanders. A total of 51 evaluation statements were rated as to their level of importance for judging maintenance technicians. There were no overall differences in the results for the repairman and mechanic supervisors. There was a difference in the ratings between supervisors and commanders. Supervisors were more concerned with the quality and detail of the maintenance activities per se, while the commanders were more concerned with the management of the maintenance function. This was not an unexpected, but it does confirm the different orientations taken in the evaluation of job proficiency.

The conclusions reached in this project were that a logical analytical process could be used to derive basic skills and knowledge and that, supervisory and management personnel are influenced by functionally related criteria for differentiating between qualified and non-qualified maintenance technicians.

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Appendix A

Task Identification Matrix

Selected Forms and Data

DATE____________

NAME (LAST, FIRST. MIDDLE INITIAL) ______ GRADE ______ AGE ______

DUTY MOS ______ ORGANIZATION ______

TIME IN PRESENT JOB ______ TOTAL TIME IN SERVICE ______

TOTAL TIME IN ELECTRONICS FIELD ______

HIGHEST SCHOOL GRADE OR COLLEGE YEAR COMPLETED ______

HOW MUCH TIME DO YOU SPEND PERFORMING SUPERVISORY OR ADMINISTRATIVE FUNCTIONS?

______NONE OF MY TIME. ______51-75% OF MY TIME.

______1-25% OF MY TIME. ______76-100% OF MY TIME.

______26-50% OF MY TIME.

HOW MUCH TIME DO YOU SPEND PERFORMING "HANDS ON" MAINTENANCE OF EQUIPMENT?

______NONE OF MY TIME. ______51-75% OF MY TIME.

______1-25% OF MY TIME. ______76-100% OF MY TIME.

______26-50% OF MY TIME.

LIST THE TYPE OF TEST EQUIPMENT YOU USE ON THE JOB (PLEASE LIST FROM MOST FREQUENTLY USED DOWN TO LEAST FREQUENTLY USED).

WHERE DID YOU LEARN TO USE THE TEST EQUIPMENT (MOS SCHOOL, OTHER SCHOOL, OR OJT)?

WHAT MAINTENANCE ACTIVITIES DO YOU PERFORM THAT WERE NOT TAUGHT IN SCHOOL OR SHOULD HAVE BEEN GIVEN MORE EMPHASIS?

Task Identification Matrix

The first column indicates the Functional Group number of the System Hardware item as referenced in the appropriate Technical Manual.

The second column indicates the total like items contained within the major item. No entry in this column indicates quantity of one.

The third column contains the short name of the Hardware item.

The fourth through seventh columns contain types of maintenance activities.

The last column is divided into two parts indicating the effect the Hardware item will have on the End item and the missile system if defective.

The column is divided into two parts for each item. The upper portion indicates the condition of the end item with the lower portion indicating the condition of the system when the particular hardware item is not functioning correctly or is missing.

R = Red indicating the end item or system is not operational if this hardware item is not functioning.

A = Amber indicating the end item or system is capable of limited operation if this hardware item is not functioning.

G = Green indicating the end item or system operation is not significantly degraded if this item is not functioning.

Functional Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
0100			Battery Control Central					R – R
1200			Power Distribution Control					R – R
1300			Synchro Buss Assembly					R – R
1400			Tactical Control Console					R – R
	1410		Relay Chassis					A – A
	1430	8	Deflection Amplifier X and Y					R – R
	1470	3	14 KV Power Supply					R – R
	1500	4	Fan and Dimmer Assembly					R – R
	1540		Relay Assembly					R – R
	1600	3	Video Amplifier					R – R
	1680		Defogging Relay Assembly					G – G
	1700		Indicator Control					R – R
	1750		Coordinate Data Control					R – R

Functional Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
	1810		Target Assigning Control					R – R
	1910		Interrogator Control					R R
	1960		Video Control Panel					R R
2100			Plotting Board					G G
2200			Plotting Board Con-trol					G – G
2300			IPAR Frequency Control					A – A
2400			Display Panel					R R
	2440		Audio Frequency Amplifier					A – A
2600			CW Target Detection Console					A – A
	2710		10KV Power Supply					A A
	2760		Video Amplifier					A A
	2810		Test Relay Assembly					R R
	2870		Control Shelf					R R
	2930		Cover Assembly					R R

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
2985		Scan Servo Assembly					R – R
3200		CWTDC Commo Unit					A – A
3300		Doppler Voice Terminal					R – R
3400		Voltage Regulator Assembly					R – R
3465	16	Voltage Regulator					R – R
3500		Reference Voltage Regulator					R – R
3600		Power Supply Control					R – R
3700		20VDC Power Supply					R – R
3800		Power Distribution Panel					R – R
3900		AADCP Local/Remote Switch					A – A
4200		Indicator Control Group					R – R
4210		General Test Set					A – G
4260		Automatic Test Set					A – G

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
4310		FC Cursor Generator					R – R
4380		IPAR Set Control					A – A
4410		TCC Cursor Generator					R – R
4510	4	TCC/FC X,Y, Electronic Clamp Assembly					R – R
4610	2	Predicted Intercept Mark Generator A&B					A – A
4730	2	FC A&B Marker Generator					A – A
4830		Symbol Intensity Electronic Gate Assembly					R – R
4930		Scale of 18 Multi-vibrator					R – R
4970		Test Set Control					R – R
5010		TCC/FC Video Mixer					R – R
5050		FC Short Sweep Generator					R – R
5150	2	TCC/FC Clamp Gate Generator					R – R

Functional Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
	5190		Symbol Generator					R – R
	5310		Symbol Multivibrator					R R
	5410		PSI Video Gate					A – A
	5540		TCC Long Sweep Generator					R – R
5700		2	Firing Console (FC "A" & "B")					A – A
	5710	2	Relay Assembly					A – A
	5830	2	Relay Chassis					A – A
	6010	2	Indicator Control					A – A
	6055	2	Cover Assembly					A – A
	6075	2	Range Control Assembly					A – A
	6195	2	Range/Speed Indicator					A – A
	6275	2	IHIPIR Azimuth Gear Train					A – A
	6415	2	Console Shelf Assembly					A – A

Function Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
	6445	2	TX Control, Manual Elevation					A – A
6600			Fire Control Group					R R
	6610	2	Range Electronic Control Amplifier "A" & "B"					A – A
	6710	2	Elevation Electronic Control Amplifier "A" & "B"					A – A
	6780	2	Azimuth Electronic Control Amplifier "A" & "B"					A – A
	6840		Height Signal Comparator					R – R
	6930		ROR Video Amplifier					A A
	7010		ROR Sweep Generator					A A
	7110		ROR Electronic Control Amplifier					A – A
	7170	2	Intercept Computer "A" & "B"					A – A
	7210	2	Firing Interlock Assembly "A" & "B"					A – A

Function Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting
7250	2	Display Generator "A" & "B"				
7290		Scan Servo Amplifier				
7360		CWTDCS Sweep Generator				
7450	2	Firing Circuits Test Set "A" & "B"				
7700		AC Lighting Power Supply				
7800		AC Filament Power Supply				
7900		28VDC Power Supply				
8100		DC Lighting Power Supply				
8200		DC Power Supply				
8300		Synchro Relay Assembly				
8400		Telephone Set and Relay Assembly				
8600		TCO/TCA Commo Unit				

Function Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
9500		Electrical Equipment Shelter Air Conditioner					R – R

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
0100		Radar Set					R – R
0500		Antenna Group					R A
0550		Pedestal Antenna					R A
0555		Brake Assembly					A G
0560		Synchro Assembly					R A
1000		Amplifier Cooler Group					R – A
1050		Amplifier Assembly					R A
1060		Dickie Fix Amplifier					A A
1070		Dickie Fix-Fix Amplifier					A – A
1080		Reciever Switch					R A
1090		Interference Blanker					R A
1105	2	Amplifier Log IF					A A
1120		Back Bias Amplifier					A A
1160		Wiring Harness					R A
1200	2	Signal Datal Converter					A A

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
1230	2	Preselector Assembly					A A
1245	2	IF Amplifier					A A
1250		Coole Unit					R A
1275	2	Gear Assembly					A A
1300	2	Magnetic Amplifier					A A
1800		Cabinet Electrical Equipment					R – A
2000		Radar Set Group					R A
2100		Commo Station					A G
2200		Indicator Azimuth Range					R – A
2215		Control Monitor					R A
2230		Sweep and Video Chassis Assembly					R – A
2245		Range Mark Generator					R A
2260		Control Power Supply					R A
2275		Wiring Harness					R A

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
2320		Indicator Assembly Azimuth Range					R – A
2328		Deflection Coil Drive					R – A
2400		Signal Comparator					R – A
2405		Amplifier Multi-vibrator					A – A
2415		Generator Video Pulse					R – A
2425	2	Delay Amplifier					A – A
2435		COHO Oscillator Assembly					A – A
2445		Test Generator					A – A
2455		MTI Amplifier					A – A
2465		Mixer Video Signal				—	R – A
2520		Wiring Harness					R – A
2600		Low Voltage Power Supply					R – A
2605	6	Voltage Regulator					R – A

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
2615		Balance Selector					R A
2620		Reference Voltage Regulator					R – A
2630		Semiconductor Device					R A
2645		Resistor Assembly					R A
2650		Resistor Assembly					R A
2655		Resistor Assembly					R A
2660	3	Resistor Assembly					R A
2665		Panel Electrical System					R – A
2700		Mount Assembly Telescope					R – A
2800		Cabinet, Electrical System					R – A
2880		Panel, Power Distribution					R – A
3000		High Voltage Power Supply					R – A
3300	3	Fan Ventilating					R A

Functional Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
	3550		Power Supply					R/A
	3600		Fan Centrifugal					R/A
	3900		Chassis Electrical Equipment					R/A
	3960		Resistor, Variable, Motor-driven					R/A
4000			Reciever-Transmitter Group					R/A
	4150		STALO Power Supply					R/A
	4155		AFC Amplifier					R/A
	4160		STALO Servo Amplifier					R/A
	4200		Pulse Generator					R/A
	4250		Trigger Pulse Amplifier					R/A
	4350		Control Oscillator (STALO)					R/A
	4360		Oscillator, Radio Frequency					R/A
	4372		Control Oscillator					R/A

Functional Group Number	Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting	
4376		Cavity, Tuned					R/A
4380		Drive Assembly, Mechanical					R – A
4390		Cabinet Electrical Equipment					R – A
4475		Mixer, AFC					R/A
4600		Pressurization Unit					R/A
4850		Cabinet, Modulator					R/A
4870		Stabilitrow Drive Assembly					R – A
4890		Stabilizer					R/A
4920		Modulator Sub-Assembly					R – A
4940		Modulator Sub-Assembly					R – A
4945		Panel Power Distribution					R – A

Appendix B

Products of Task Analytical Process Model

B-1 Electronic Concepts

B-1-1 Voltage

B-1-2 Performs electrical alinement

B-1-3 Attenuates signals

B-1-4 Electrically grounds equipment etc. (Recalls what happens or doesn't happen when something is grounded or not grounded).

B-1-5 Recognizes in-phase and out-of-phase signals.

B-1-6 Interprets information as input to decision for subsequent action.

B-1-7 Discriminates between signals and noise on oscilloscope presentation.

B-1-8 Relates amplitude level to amount of voltage.

B-1-9 Recognizes indication of non-normal Bi-Polar Video signals.

B-1-10 Recognizes indications of optimum Bi-Polar Video amplitudes.

B-1-11 Refers to radar transmitter and receiver theory of operation.

B-1-12 Recalls insulative properties of common materials.

B-1-13 Recalls conductive properties of common materials.

B-1-14 Recalls positive/negative electrical potential.

B-1-15 Applies the theory of Direct Current (DC) in diagnosing and correcting electronic malfunctions.

B-1-16 Adjusts equipment until desired indication is obtained (light "just" goes out - "just" stops oscillating).

B-1-17 Adjust equipment for a null indication (null is not to be confused with zero).

B-1-18 Inspect electronic equipment for physical damage and the presence of moisture and other contaminants.

B-1-19 Recalls and uses electronic symbology notations and values.

B-1-20 Identifies diodes.

B-1-21 Recalls alternating current (AC) theory.

B-1-22 Uses resonant circuit theory (Frequency, Bandwidth, Center Frequency and Bandpass).

B-1-23 Discriminates and interprets complex electronic signals, comparing leading and trailing edges to determine time relationships.

B-1-24 Recalls that time is displayed and measured along the horizontal plane on the oscilloscope.

B-1-25 Uses theory of magnetism in selection of tools.

B-1-26 Uses Ohms Law, (theory of resistance) in troubleshooting circuitry.

B-1-27 Uses and checks coaxial cables based on knowledge of construction and function of coaxial cable.

B-1-28 Uses Radio frequency probes (RF probes) that are impedance matched and calibrated with a particular meter.

B-1-29 Select proper test equipment to measure RF signals.

B-1-30 When working with vacuum tubes refers to vacuum tube theory when interpreting signal information.

B-1-31 When working with resistors refers to resistor theory when interpreting signal information.

B-1-32 When working with capacitors refers to capacitor theory when interpreting signal information.

B-1-33 Isolates causes of malfunction in electronic equipment.

B-1-34 When working with circuit cards, refers to theory of transistor operation to determine signal inputs and outputs.

B-1-35 When working with circuit cards, refers to theory of diode operation to determine signal inputs and outputs.

B-1-36 When working with transformer refers to transformer theory when interpreting signal information.

B-1-37 When working with relays refers to relay theory when interpreting signal information.

B-1-38 When working with antennas and waveguides refers to RF microwave theory to interpret signal information.

B-1-39 When working with electric motors (AC or DC) refers to motor theory to interpret signal information.

B-1-40 When working with pressurization units refers to compressor theory to interpret signal information.

B-1-41 When working with pumps (liquid) refers to pump theory to interpret signal information.

B-1-42 When working with antenna positioning systems refers to parallax theory and antenna control system theory to interpret signal information.

B-2 **Tools**

B-2-1		**Uses attenuator probes.**
B-2-2		**Uses jumper leads.**
B-2-3		**Uses hand tools.**
B-2-3-1		**Screwdrivers - flat tip**
	2	**Screwdrivers - cross tip (Phillips)**
	3	**Hexagon headed - L shaped (Allen wrenches)**
	4	**Open end wrenches**
	5	**Rulers**
	6	**Pliers**
	7	**Torque wrenches**
B-2-4		**Uses soldering sets**
B-2-4-1		**Soldering Irons**
	2	**Soldering Aids**
	3	**Heat Syncs**
	4	**Solder**
	5	**Flux**
B-2-5		**Uses - Thickness Guage**
B-2-6		**Uses - Dial Indicators**
B-2-7		**Uses - Non magnetic tools and tuning wands**
B-2-8		**Uses - RF Probes**
B-2-9		**Uses - Card Extractors**

B-3 Hardware

B-3-1 Uses gaskets

B-3-2 Uses nuts and bolts

B-3-3 Identifies threaded - unthreaded holes

B-3-4 Uses Index pins (locking pins for gear assembly)

B-3-5 Uses retaining clamps and screws

B-3-6 Uses turnlock fasteners

B-3-7 Uses set screws

B-3-8 Uses coaxial cables

B-3-9 Uses TEE connectors

B-3-10 Uses BSM connectors

B-3-11 Uses fuses

B-3-12 Uses clamps (light bulbs)

B-3-13 Uses wire

B-3-14 Uses waveguide

B-3-15 Uses dessicant

B-3-16 Uses filters - air and liquid

B-3-17 Uses coolant fluid and lubricants

B-3-18 Uses coaxial connectors

B-3-19 Uses plugs, connectors, and jacks.

B-4 Test Equipment

B-4-1 Uses - Multimeter

B-4-2 Uses - Oscilloscope

B-4-3 Uses - Electronic Voltmeter

B-4-4 Uses TS-505 A/U multimeter

B-4-5 " " " B/U multimeter

B-4-6 " " " C/U multimeter

B-4-7 " " " D/U multimeter

B-4-8 Insulates multimeter from metal portion of radar.

B-4-9 Recalls that case of the TS-505 A/U - B/U - C/U multimeters have a high positive potential.

B-4-10 Does not touch the case of the TS-505 A/U, B/U or C/U multimeter after leads are connected to test jack.

B-4-11 Grounds the TS-505 D/U multimeter when it is to be used and does not need to insulate it.

B-4-12 Obtains minimum meter indications.

B-4-13 Determines oscillation as a movement at a steady rate between two limits.

B-4-14 Uses a stop watch.

B-4-15 Interprets meter reading as input decision for subsequent action.

B-4-16 Uses high frequency console.

B-4-16-1 Multimeter A & B

2 Dual Pulse Generator

3 Oscilloscope

4 Multifunction Generator

5 Modulator Oscillator

6 600 Ohm Attenuators

7 CW Oscillator

8 Amplifier Indicator

9 Thermal noise generator

10 Signal Generator

11 50 Mhz Counter

B-4-17 Interprets simple and complex wareforms presented as signal on oscilliscope.

B-4-18 Uses tube adapter

B-4-19 Uses tube tester (TV-7)

B-4-20 Uses digital volt meter

B-4-21 Uses a wavemeter

B-5 Mechanical Skills

B-5-1 Uses degrees in a circle to determine or locate a position.

B-5-2 Turns controls in a clockwise or counterclockwise direction.

B-5-3 Mechanically aligns synchros to zero.

B-5-4 Discriminates between specific gears using references, drawings or diagrams.

B-5-5 Mechanically centers potentionmeters.

B-5-6 Removes and installs index pins correctly.

B-5-7 Applies pressure to remove mechanical error from gear assemblies.

B-5-8 Removes and installs diodes.

B-5-9 Removes and installs gears and other mechanical components.

B-5-10 Checks gear assemblv backlash.

B-5-11 Adusts gear backlash.

B-5-12 Adjusts mechanical components to a specified tolerance.

B-5-13 Greases and oils gears and gear train components.

B-5-14 Installs and uses tube adapters.

B-5-15 Installs and removes vacuum tubes.

B-5-16 Installs and removes circuit cards.

B-5-17 Installs and removes relays.

B-5-18 Installs and removes transformers.

B-5-19 Installs and removes resistors.

B-5-20 Installs and removes capacitors.

B-5-21 Installs and removes chassis.

B-5-22 Installs and removes switches.

B-5-23 Installs and removes fuses and lamps.

B-5-24 Installs waveguide.

B-5-25 Installs antennas.

B-5-26 Installs and removes electric motors.

B-5-27 Installs and removes pressurization units.

B-5-28 Installs and removes dessicant.

B-5-29 Installs and removes pumps.

B-5-30 Installs and removes air filters.

B-5-31 Installs and removes fluid filters.

B-5-32 Installs coaxial connectors.

B-5-33 Installs plugs, connectors and jacks.

B-5-34 Fabricates gaskets.

B-5-35 Fabricates cables.

B-6 Mathematic Concepts

B-6-1 Uses "ratio".

B-6-2 Uses symbol to represent mathematical values.

B-6-3 Uses addition, subtraction and division, performs comparisions.

B-6-4 Uses basic geometry - (radius, degrees in a circle etc.)

B-6-5 Uses inch and or foot pounds in determining and measuring torque values.

B-6-6 Uses concepts of maximum and minimum.

B-6-7 Plots information on a scale or a graph.

B-6-8 Interprets and uses information contained on a graph or scale.

B-6-9 Recalls and uses geometric terms.

B-6-9-1 Intersect

2 Rectangle

3 Vertical

4 Horizontal

B-6-10 Uses positive and negative values.

B-6-11 Uses time measurements.

B-6-12 Uses Binary numbering system.

B-6-13 Uses Octal numbering system.

B-6-14 Uses Hexa decimal numbering system.

B-6-15 Uses Boolean Algebra.

B-6-16 Uses Logic Diagrams.

B-6-17 Uses Truth Tables.

B-6-18 Converts Binary values to and from.

B-6-18-1 Decimal values

2 Octal values

3 Hexadecimal values

B-6-19 Reads and interprets Fluid and Air pressure gauges (PSI).

B-6-20 Recalls and uses Parallax System theory.

B-7 Electronic Components

B-7-1 Uses (removes, replaces, selects) switches.

B-7-2 Uses variable resistors.

B-7-3 Locates physical position of components and chassis.

B-7-4 Electrically aligns synchros.

B-7-5 Uses data and power cables.

B-7-6 Locates test points on equipment.

B-7-7 Locates ground points on equipment.

B-7-8 Adjusts controls to obtain proper indication.

B-7-9 Recognizes indications of improper equipment conditions.

B-7-10 Takes corrective action when indications of improper conditions occur.

B-7-11 Uses, replaces Cathode Ray Tubes (CRT).

B-7-12 Makes corrections and disconnections of various types of multi connector power, data and coaxial cables.

B-7-13 Uses capacitors.

B-7-14 Uses vacuum tubes.

B-7-15 Uses resistors.

B-7-16 Uses circuit cards.

B-7-17 Uses transformers.

B-7-18 Uses relays.

B-7-19 Uses electric motors.

B-7-20 Uses fluid pumps.

B-7-21 Uses pressurization units (Compressors - Air).

B-8 Electronic Circuits

B-8-1 Applies vacuum tube theory in working with the following circuits.

B-8-1-1 Amplifiers - (Single and multistage).

2 Cathode followers

3 Multivibrators

4 Power supplies

5 Voltage regulators

6 Oscillators

7 Sweep generators

8 Timing - (Pulse)

9 Display (CRT)

10 High voltage power supplies and regulators

11 Clamping - Limiters

12 Noise generators

B-8-2 Uses schematics.

B-8-3 Uses technical maintenance manuals.

B-8-4 Uses supply (repair part) manuals.

B-8-5 Uses flow charts.

B-8-6 Applies solid state theory in working with the following circuits.

B-8-6-1 AND - Gates

2 OR - Gates

3 NOR - Gates

4 NAND - Gates

5 Flip Flops

B-8-6-6 Drivers

7 Amplifiers - single and multistage

8 Adders

9 Counters

10 Power Supplies

11 Input Circuits

12 Output Circuits

13 Oscillators

14 Couplers

B-8-7 Applies microwave theory (RF theory) in working with the following circuits.

B-8-7-1 Transmitter lines and antennas

2 Oscillators

3 Amplifiers

4 Amplitude Modulation

5 Frequency Modulation

6 Pulse Modulation

7 Detectors

8 Frequency Convertors

B-8-8 Antenna positioning circuits

B-8-9 Parallax circuits

B-9 General Electrical and Mechanical Equipment

B-9-1 Tightens synchros maintaining a specific meter reading.

B-9-2 Recalls electro - mechanical servo systems functional operation.

B-9-3 Energizes and de-energizes equipment.

B-9-4 Uses gear trains.

B-9-5 Uses resolvers.

B-9-6 Uses computers.

B-9-7 Uses motors.

B-9-8 Uses pumps.

B-9-9 Uses pressurization units (Compressors).

Appendix B

Safe Working Procedures

Using safe working procedures include the following:

1. De-energizes (turns OFF) equipment when removing and replacing chassis and components, and connecting test equipment leads.

2. Discharges capacitors in high voltage power supplies, regulators and transmitters before working with or around them.

3. Properly grounds equipment prior to applying power.

4. Keep hands or other parts of the body out of energized equipment, especially in areas where vision is obstructed.

5. Removes hand jewelry and dangling necklaces, chains, etc. before working on energized equipment (or tape them so they won't get caught).

6. Practices the "one hand" rule when working with conductive materials.

7. Does not sit or lean on energized equipment.

8. Keeps equipment dry when working under incliment weather conditions.

9. Does not use water to put out electrical fixes.

10. Never works alone around energized equipment.

11. Uses appropriate safety devices and equipment, such as hooks, ropes, poles, rubber gloves, goggles and first aid equipment, when called for.

12. Immediately turns off power if energized equipment gets wet.

13. Stays alert and does not engage in horseplay around energized equipment.

14. Does not allow test equipment leads, tools, wires, etc. short circuit components.

15. Inspects switches and connector wires for servicability

Cont.

(looks for bare wires, sparks, excessive heat).

16. Does not cheat safety interlocks except when referenced procedures specifically call for it.

17. Wears safety goggles and gloves when handling radioactive materials or glass tubes.

18. Disposes of radioactive materials and glass tubes in the prescribed manner.

19. Does not work on energized equipment when sleepy or under the influence of medication, drugs or alcohol.

20. Does not work under suspended loads.

Appendix B

Use of Good Work Habits

Good work behaviors include the following:

1. Plans the job - determining what activities must be carried, assembling the necessary tools, test equipment, schematics, Technical Manuals (TM's) and other references prior to starting the work.

2. Recognizes working difficulties as they develop during work performance, analyzes the problem, makes a decision as to what action to take and takes the corrective action.

3. Uses proper tools, test equipment materials and references.

4. Removes and replaces parts/components correctly by performing all necessary steps and using all required hardware (screws, nuts, washers, bolts, etc.).

5. Inspects all tools, equipment, materials, hardware and components as they are used.

6. Replaces all damaged parts/components with serviceable ones.

7. Assumes responsibility for all of his work activities.

8. Performs each task thoroughly but efficiently.

9. Does not jump to conclusions.

10. Double checks switch positions cable connections, etc., prior to completing repair and diagnosis activities.

11. Performs work conscientiously, completely, and accurately.

12. Initiates any maintenance activities that must be performed, but not necessarily specifically assigned.

Diagnosis of Electronic Malfunctions

Steps:

1. Identify the Problem.

   All symptoms must be analyzed to determine the problem.

2. Recall relative information.

   Items of information that are known, have been previously catalouged and have a relation to the problem must be considered.

3. Unknowns must be identified.

   There must be a recognition of those items of information that are necessary but are at present unknown. This unknown information must be acquired.

4. Propose a solution.

   A possible solution must be framed and evaluated to determine if the proposed solution conforms to the known information.

5. Testing the solution.

   a. After the proposed solution is framed and evaluated, the proposed solution must be implemented, (tested), on the physical equipment.

6. b. Evaluate and revise the proposed solution. Where the facts, (results) are in conflict with the proposed solution. (Did not isolate or identify the cause of malfunction).

7. Decision:

   When the proposed solution has been evaluated and the cause of malfunction isolated, a decision is now made to correct (repair) the cause of malfunction.

Appendix C

Task Analytical Process Model

Detailed Summary of Skills and Knowledge

B-1 - Electronic Concepts

	1	2	3	4	5	6	7	8	9
Totals	87	26	29	37	221	284	960	63	79
Skill Numbers									
B-1-1				6	3				
B-1-2	6		5						
B-1-3	3					17			
B-1-4	11	5					3	3	1
B-1-5	3								
B-1-6	15		12	5	120	91	284	22	23
B-1-7	9					21	37		
B-1-8	5					11	37		16
B-1-9	2								
B-1-10	2								
B-1-11	2	2							
B-1-12	3	1		1	1	1	2	1	1
B-1-13	3	1							
B-1-14	3	1					268	1	
B-1-15	6	5					11		
B-1-16	6	11	12	25	97	35	24	11	24

Task Numbers									
10	11	12	13	14	15	16	17	18	Totals
96	209	6	27	20	27	123	372	408	3074
	9		2		2	7	5	2	36
									11
8	3					22			53
2	5		2	1	2		1		36
1									4
17	40	2	4	6	6	17	57	85	806
12	9						44	53	185
8	6					8	55	64	210
							1		3
						1			3
									4
1	5					6	39		62
	5					6	7		22
						4	5	67	349
	12					6	5	5	50
						2		13	260

	1	2	3	4	5	6	7	8	9
B-1-17	8								
B-1-18						1	1		1
B-1-19						101	278	17	10
B-1-20								1	
B-1-21							10	1	
B-1-22									
B-1-23									
B-1-24									
B-1-25									
B-1-26						6	5	6	3
B-1-27									
B-1-28									
B-1-29									
B-1-30									
B-1-31									
B-1-32									
B-1-33									
B-1-34									
B-1-35									

Task Numbers

10	11	12	13	14	15	16	17	18	Total
									8
	7	2		3		2	1		18
28	20					7	73	64	598
								2	3
	6		5		6	3	3	5	39
3									3
2									2
7							7	32	46
1						4	42	5	52
6	17		3		3		5		54
	2								2
	3								3
	4					5			9
	13					7	5		25
	12			5		7	5	4	33
	12			5		2	2	2	23
	17					1	5	2	25
	2								2
						2		2	4

	1	2	3	4	5	6	7	8	9
B-1-36									
B-1-37									
B-1-38									
B-1-39									
B-1-40									
B-1-41									
B-1-42									

Task Numbers									
10	11	12	13	14	15	16	17	18	Total
			3		3	2	5	1	14
			3			2			5
			3		3				6
			2						2
		2			2				4

B-2 - Tools

	1	2	3	4	5	6	7	8	9
Totals	112	8	17	27	32	21	17	31	31
Skill Numbers									
B-2-1	2					21	12	5	
B-2-2	4								
B-2-3-1	106	8	12	21	32		5	5	1
B-2-3-2								6	
B-2-3-3			5						22
B-2-3-4				5					
B-2-3-5				1				4	
B-2-3-6								3	
B-2-3-7									1
B-2-4-1								2	
B-2-4-2								2	
B-2-4-3								2	
B-2-4-4								1	
B-2-4-5								1	
B-2-5									2
B-2-6									5
B-2-7									
B-2-8									
B-2-9									

Task Numbers

10	11	12	13	14	15	16	17	18	Total
28	8	6	14	13	14	38	12	33	462
17						5		10	72
			1		1	6			12
		2						1	193
		2	2	3	2	5		10	30
			2	3	2				34
		2	3	2	3				15
				3					8
			1	2	1	2	2	2	13
									1
			1		1	4	2	2	12
			1		1	4	2	2	12
			1		1	4	2	2	12
			1		1	4	2	2	11
			1		1	4	2	2	11
									2
									5
3									3
8	8								16
									--

B-3 - Hardware

	1	2	3	4	5	6	7	8	9
	3	12	14	32	-	-	-	-	8
B-3-1									
B-3-2	2			20					
B-3-3	1								
B-3-4		5	4						4
B-3-5		7	10						
B-3-6				5					
B-3-7				7					2
B-3-8									
B-3-9									2
B-3-10									
B-3-11									
B-3-12									
B-3-13									
B-3-14									
B-3-15									
B-3-16									
B-3-17									
B-3-18									
B-3-19									

Task Numbers

10	11	12	13	14	15	16	17	18	Total
--	6	14	20	28	16	13	11	25	202
		2	6	4	2				14
		2	5	6	2	4	2	2	45
									1
			2		2				17
			3		2				22
		2		2					9
									9
	2					2	2	6	12
	2					2	2	6	14
	2					2	2	5	11
						2	2	5	9
						1	1	1	3
				2					2
			2	4					6
		2		3	3				8
		2			3				5
		2		3					5
		2	2	4	2				10

B-4 - Test Equipment

	1	2	3	4	5	6	7	8	9
Totals	93	30	1	-	4	182	556	30	63
Skill Numbers									
B-4-1	14	10							
B-4-2	12								
B-4-3	10								
B-4-4	3	1							
B-4-5	3	1							
B-4-6	3	1							
B-4-7	3	1							
B-4-8	3	1							
B-4-9	3	1							
B-4-10	3	1							
B-4-11	3	1							
B-4-12	1	1							2
B-4-13	3	1	1						
B-4-14	3				4			1	
B-4-15	14	10				25	239		33
B-4-16						1	1	1	1
B-4-16-1						33	231	13	27
B-4-16-2						16	9	1	

Task Numbers

10	11	12	13	14	15	16	17	18	Total
101	88	--	4	--	4	28	170	201	1,555
			2		2				28
									12
									10
									4
									4
									4
									4
									4
									4
									4
									4
									4
									5
									8
23	24		2		2	14	27	15	428
1	11					2	1		19
11	25					12	20	32	404
3							5	1	35

	1	2	3	4	5	6	7	8	9
B-4-16-3						27	37	7	
B-4-16-4						6	1		
B-4-16-5						2			
B-4-16-6						2			
B-4-16-7						2			
B-4-16-8						2			
B-4-16-9						2			
B-4-16-10						6			
B-4-16-11						31	1	5	
B-4-17	12					27	37	2	
B-4-18									
B-4-19									
B-4-20									
B-4-21									

Task Numbers									
10	11	12	13	14	15	16	17	18	Total
19	7						60	79	236
2									9
									2
3									5
									2
									2
									2
8	8						1	1	24
9	7						1	7	61
21	6						55	66	226
1									1

B-5 - Mechanical Skills

	1	2	3	4	5	6	7	8	9
Totals	48	4	17	-	31	33	22	20	73
Skill Numbers									
B-5-1	12				5				
B-5-2	24	4	10		26	25	22	14	17
B-5-3	4		1						
B-5-4	3		1						21
B-5-5	5		2			8		4	
B-5-6			2						5
B-5-7			1						8
B-5-8								2	
B-5-9									2
B-5-10									5
B-5-11									7
B-5-12									7
B-5-13									1
B-5-14									
B-5-15									
B-5-16									
B-5-17									
B-5-18									

Task Numbers

10	11	12	13	14	15	16	17	18	Total
9	12	9	17	20	17	5	16	17	370
									17
4			2	4	3	2	7	6	170
									5
									25
							6	5	30
					2				9
									9
									2
									2
									5
									7
			2	2	2				13
			1	2	1				5
1									1
4	12								16
									--
			1			1			2
			1		1			1	3

	1	2	3	4	5	6	7	8	9
B-5-19									
B-5-20									
B-5-21									
B-5-22									
B-5-23									
B-5-24									
B-5-25									
B-5-26									
B-5-27									
B-5-28									
B-5-29									
B-5-30									
B-5-31									
B-5-32									
B-5-33									
B-5-34									
B-5-35									

Task Numbers									
10	11	12	13	14	15	16	17	18	Total
						1		1	2
							1	1	2
				2				1	3
									–
				2		1	2	2	7
									–
									–
			1		1				2
			1	2					3
			1	4					5
		2							2
		1			1				2
		4			2				6
									–
		2	2	2	2				8
			3						3
			2		2				4

B-6 - Mathematic Skills

	1	2	3	4	5	6	7	8	9
Totals	3	-	-	-	-	82	291	19	38
Skill Numbers									
B-6-1	3						1		
B-6-2						72	282	13	28
B-6-3						10	8	6	
B-6-4									5
B-6-5									5
B-6-6									
B-6-7									
B-6-8									
B-6-9									
B-6-9-1									
B-6-9-2									
B-6-9-3									
B-6-9-4									
B-6-10									
B-6-11									
B-6-12									
B-6-13									
B-6-14									

Task Numbers

10	11	12	13	14	15	16	17	18	Totals
74	40	3	2	2	2	2	64	142	764
3								3	10
24	21					2	64	79	585
15	11							48	98
									5
									5
5	6								11
4									4
3									3
									–
1									1
1									1
4									4
3	1								4
4	1							5	10
7								7	14
									--
									--
									--

	1	2	3	4	5	6	7	8	9
B-6-15									
B-6-16									
B-6-17									
B-6-18									
B-6-18-1									
B-6-18-2									
B-6-18-3									
B-6-19									
B-6-20									

Task Numbers

10	11	12	13	14	15	16	17	18	Total
									--
									--
									--
									--
									--
									--
									--
		3	2	2	2				9
									--

B-7 - Electronic Components

	1	2	3	4	5	6	7	8	9
Totals	497	107	77	138	770	514	961	201	108
Skill Numbers									
B-7-1	174	36	15	6	128	148	230	64	23
B-7-2	19				71	24	38	10	2
B-7-3	87	10	18	35	156	81	15	17	19
B-7-4	9	1							
B-7-5	1		4						
B-7-6	65	20				4	23	12	
B-7-7	40	3				4	2	4	2
B-7-8	24	9	12	25	110	35	18	11	
B-7-9	26	9	12	26	155	67	285	22	22
B-7-10	32	9	12	26	146	62	277	22	22
B-7-11				10	4			11	
B-7-12	20	10	4	10		89	73	28	18
B-7-13									
B-7-14									
B-7-15									
B-7-16									
B-7-17									
B-7-18									

Task Numbers									
10	11	12	13	14	15	16	17	18	Totals
189	292	10	27	10	18	107	381	469	4,876
50	30	6	2	4	2	20	56	132	1,126
7	21		1			2	6	19	220
20	7		3		2	17	6	6	499
3	6								19
									5
11	28		4		2	19	57	41	286
1	27		2		1	6	9	8	109
15	12		3	2			43	31	350
22	37		2		2	10	80	83	860
22	35		2		2	3	80	74	826
									25
38	35		4		4	20	38	71	462
	18					2			20
	18					2	2	2	24
	18					3	4	1	26
									--
			1		1	1		1	4
			1			2			3

	1	2	3	4	5	6	7	8	9
B-7-19									
B-7-20									
B-7-21									

Task Numbers									
10	11	12	13	14	15	16	17	18	Total
		2	1	2	1				6
		2			1				3
			1	2					3

B-8 - Electronic Circuits

	1	2	3	4	5	6	7	8	9
Totals	3	3	3	3	2	2	13	6	3
Skill Numbers									
B-8-1									
B-8-1-1									
B-8-1-2									
B-8-1-3									
B-8-1-4									
B-8-1-5									
B-8-1-6									
B-8-1-7									
B-8-1-8									
B-8-1-9							1		
B-8-1-10									
B-8-1-11									
B-8-1-12									
B-8-2	1	1	1	1			6	3	1
B-8-3	1	1	1	1	1	1	3	1	1
B-8-4	1	1	1	1	1	1	3	2	1
B-8-5									
B-8-6									

10	11	12	13	14	15	16	17	18	Totals
6	29	--	--	--	--	20	20	20	133
	22					1		1	24
							3	1	4
							2		2
						2			2
						2	1	1	4
								1	1
								1	1
							2	1	3
									1
						3			3
						2		2	4
									–
2	3					5	5	5	34
2	2					3	5	4	27
2	2					2	2	3	23
									--
									--

	1	2	3	4	5	6	7	8	9
B-8-6-1									
B-8-6-2									
B-8-6-3									
B-8-6-4									
B-8-6-5									
B-8-6-6									
B-8-6-7									
B-8-6-8									
B-8-6-9									
B-8-6-10									
B-8-6-11									
B-8-6-12									
B-8-6-13									
B-8-6-14									
B-8-7									
B-8-7-1									
B-8-7-2									
B-8-7-3									
B-8-7-4									

10	11	12	13	14	15	16	17	18	Total
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--
									--

	1	2	3	4	5	6	7	8	9
B-8-7-5									
B-8-7-6									
B-8-7-7									
B-8-7-8									
B-8-8									
B-8-9									

10	11	12	13	14	15	16	17	18	Total
									--
									--
									--
									--
									--
									--

B-9 - General Electrical Mechanical Equipment

	1	2	3	4	5	6	7	8	9
Totals	12	-	14	-	-	-	-	-	17
Skill Numbers									
B-9-1	6		7						12
B-9-2	6		7						
B-9-3									
B-9-4									2
B-9-5									3
B-9-6									
B-9-7									
B-9-8									
B-9-9									

10	11	12	13	14	15	16	17	18	Total
--	--	7	5	4	6	--	3	3	71
									25
									13
		3	3		3		3	3	15
									2
									3
									–
		2	1	2	2				7
		2			1				3
			1	2					3

B-1 - Electronic Concepts	Task Numbers 19	20	21		19	20	21		19	20	21
Skill Numbers				Skill Numbers				Skill Numbers			
B-1-1	x	x	x	B-1-16	x	x	x	B-1-31		x	x
B-1-2		x	x	B-1-17	x	x	x	B-1-32		x	x
B-1-3	x	x	x	B-1-18		x	x	B-1-33	x	x	x
B-1-4		x	x	B-1-19	x	x	x	B-1-34	x		
B-1-5	x	x	x	B-1-20			x	B-1-35	x	x	x
B-1-6	x	x	x	B-1-21	x		x	B-1-36		x	x
B-1-7	x	x	x	B-1-22	x		x	B-1-37		x	x
B-1-8	x		x	B-1-23			x	B-1-38		x	x
B-1-9		x	x	B-1-24	x	x	x	B-1-39			x
B-1-10	x		x	B-1-25			x	B-1-40			x
B-1-11	x	x	x	B-1-26	x	x	x	B-1-41			x
B-1-12	x	x	x	B-1-27	x			B-1-42		x	
B-1-13	x	x	x	B-1-28			x				
B-1-14		x	x	B-1-29			x				
B-1-15		x	x	B-1-30		x	x				

B-2-Tools	Task Numbers 19	20	21		Task Numbers 19	20	21	B-3-Hardware	Task Numbers 19	20	21
Skill Numbers								Skill Numbers			
B-2-1		x	x	B-2-6				B-3-1		x	x
B-2-2	x	x	x	B-2-7			x	B-3-2		x	x
B-2-3-1	x	x	x	B-2-8	x		x	B-3-3		x	x
B-2-3-2		x	x	B-2-9	x			B-3-4		x	x
B-2-3-3		x	x					B-3-5		x	x
B-2-3-4		x	x					B-3-6	x	x	x
B-2-3-5		x	x					B-3-7	x	x	x
B-2-3-6		x	x					B-3-8		x	x
B-2-3-7			x					B-3-9		x	x
B-2-4-1	x	x	x					B-3-10		x	x
B-2-4-2	x	x	x					B-3-11		x	x
B-2-4-3	x	x	x					B-3-12		x	x
B-2-4-4	x	x	x					B-3-13		x	x
B-2-4-5	x	x	x					B-3-14			x
B-2-5								B-3-15			x

B-3-Hardware	Task Numbers 19	20	21	B-4-Test Equipment	Task Numbers 19	20	21		Task Numbers 19	20	21
Skill Numbers				Skill Numbers							
B-3-16			x	B-4-1		x	x	B-4-16			
B-3-17			x	B-4-2	x	x	x	B-4-16-1			
B-3-18		x	x	B-4-3		x	x	B-4-16-2			
B-3-19		x	x	B-4-4		x	x	B-4-16-3			
				B-4-5		x	x	B-4-16-4			
				B-4-6		x	x	B-4-16-5			
				B-4-7		x	x	B-4-16-6			
				B-4-8		x	x	B-4-16-7			
				B-4-9		x	x	B-4-16-8			
				B-4-10		x	x	B-4-16-9			
				B-4-11		x	x	B-4-16-10			
				B-4-12		x	x	B-4-16-11			
				B-4-13		x	x	B-4-17	x	x	x
				B-4-14		x	x	B-4-18			x
				B-4-15	x	x	x	B-4-19	x		x

B-4-Test Equipment	Task Numbers 19	20	21	B-5-Mechanical Skills	Task Numbers 19	20	21		Task Numbers 19	20	21
Skill Numbers				Skill Numbers							
B-4-20	x		x	B-5-1		x	x	B-5-16	x	x	x
B-4-21	x		x	B-5-2	x	x	x	B-5-17	x	x	x
				B-5-3		x	x	B-5-18		x	x
				B-5-4		x	x	B-5-19		x	x
				B-5-5	x	x	x	B-5-20		x	x
				B-5-6		x	x	B-5-21	x	x	x
				B-5-7		x	x	B-5-22	x	x	x
				B-5-8	x	x	x	B-5-23	x	x	x
				B-5-9		x	x	B-5-24			x
				B-5-10		x	x	B-5-25			x
				B-5-11		x	x	B-5-26		x	x
				B-5-12		x	x	B-5-27			x
				B-5-13		x	x	B-5-28			x
				B-5-14		x	x	B-5-29			x
				B-5-15	x	x	x	B-5-30			x

B-5-Mechanical Skills	Task Numbers 19	20	21	B-6-Mathematic Skills	Task Numbers 19	20	21		19	20	21
Skill Numbers				Skill Numbers							
B-5-31			x	B-6-1	x			B-6-12	x		
B-5-32	x	x	x	B-6-2	x	x	x	B-6-13	x		
B-5-33	x	x	x	B-6-3		x	x	B-6-14	x		
B-5-34	x	x	x	B-6-4				B-6-15	x		
B-5-35		x	x	B-6-5			x	B-6-16	x		
				B-6-6			x	B-6-17	x		
				B-6-7	x			B-6-18			
				B-6-8	x		x	B-6-18-1	x		
				B-6-9				B-6-18-2	x		
				B-6-9-1		x	x	B-6-18-3	x		
				B-6-9-2		x	x	B-6-19		x	x
				B-6-9-3		x	x	B-6-20		x	
				B-6-9-4		x	x				
				B-6-10	x	x	x				
				B-6-11	x	x	x				

B-7-Electronic Components	Task Numbers				Task Numbers			B-8-Electronic Circuits	Task Numbers		
	19	20	21		19	20	21		19	20	21
Skill Numbers								Skill Numbers			
B-7-1	x	x	x	B-7-16	x	x	x	B-8-1			
B-7-2	x	x	x	B-7-17		x	x	B-8-1-1		x	x
B-7-3	x	x	x	B-7-18		x	x	B-8-1-2		x	x
B-7-4		x	x	B-7-19		x	x	B-8-1-3		x	x
B-7-5		x	x	B-7-20			x	B-8-1-4		x	x
B-7-6	x	x	x	B-7-21		x	x	B-8-1-5		x	x
B-7-7	x	x	x					B-8-1-6			x
B-7-8	x	x	x					B-8-1-7			x
B-7-9	x	x	x					B-8-1-8			x
B-7-10	x	x	x					B-8-1-9		x	x
B-7-11			x					B-8-1-10			x
B-7-12	x	x	x					B-8-1-11			x
B-7-13		x	x					B-8-1-12			x
B-7-14		x	x					B-8-2	x	x	x
B-7-15		x	x					B-8-3	x	x	x

B-8-Electronic Circuits	Task Numbers 19	20	21		Task Numbers 19	20	21	B-9-General Electrical Mechanical Equipment	Task Numbers 19	20	21
Skill Numbers								Skill Numbers			
B-8-4	x	x	x	B-8-6-13	x			B-9-1			
B-8-5	x		x	B-8-6-14	x			B-9-2		x	x
B-8-6				B-8-7				B-9-3	x	x	x
B-8-6-1	x			B-8-7-1			x	B-9-4		x	x
B-8-6-2	x			B-8-7-2			x	B-9-5		x	x
B-8-6-3	x			B-8-7-3			x	B-9-6	x	x	
B-8-6-4	x			B-8-7-4			x	B-9-7	x	x	x
B-8-6-5	x			B-8-7-5			x	B-9-8			x
B-8-6-6	x			B-8-7-6			x	B-9-9			x
B-8-6-7	x			B-8-7-7			x				
B-8-6-8	x			B-8-7-8			x				
B-8-6-9	x			B-8-8		x					
B-8-6-10	x			B-8-9		x					
B-8-6-11	x										
B-8-6-12	x										

Appendix D

Electronic Maintenance Job Description Survey

Electronic Maintenance Job Description Survey

Introduction

This survey has been developed from the analysis of tasks from several electronic maintenance MOS('s). Its purpose is to obtain job description data that will be used to develop new or modify existing electronic maintenance courses conducted by the U.S. Army Schools. We realize that some of the items in this survey may describe skills, knowledge or activities that may not be important in your job, but they are included because they are important in other jobs. Much of the material used here was found to be used to some extent in many if not all the MOS('s) analyzed. You and many other electronic technicians are being asked to fill out the survey so that it can be determined how important each item is to successful performance on the job. The idea is to be able to develop courses where only job-important material is covered. Your sincere effort in answering each item will be appreciated. Those who will follow you in your MOS will thank you for your effort in providing this input to the development of improved maintenance course content.

PART I - GENERAL WORK HABITS AND SAFE OPERATING PROCEDURES.

For each item, indicate how important you feel it is to the overall success of your job. Use the scale 1 to 10, with 1 being the lowest and 10 the highest level of importance.

0 1 2 3 4 5 6 7 8 9 10

Not important — Extremely important

G1. Planning the job - determining what activities must be carried out, assembling the necessary tools, test equipment, schematics, technical manuals, and other references prior to starting the work. _____

G2. Detecting problem situations as soon as they develop. _____

G3. Analyzing problem situations that are blocking work progress. _____

G4. Taking action to overcome work situation difficulties. _____

G5. Using the proper tools to carry out a procedure. _____

G6. Using the proper test equipment. _____

G7. Using the appropriate materials in servicing equipment. _____

G8. Performing all necessary steps in removing and/or replacing components/parts. _____

G9. Using all required hardware (nuts, screws, washers, bolts, etc.) when replacing components/parts. _____

G10. Inspecting all tools for serviceability before using. _____

G11. Inspecting all test equipment for serviceability before using. _____

G12. Inspecting all materials before using. ______

G13. Inspecting all components/parts before using. ______

G14. Recognizing that components/parts are damaged. ______

G15. Replacing damaged components/parts. ______

G16. Assuming personal responsibility for all assigned and implied MOS duties. ______

G17. Performing each task thoroughly, and not taking shortcuts or jumping to conclusions. ______

G18. Double checking switch positions, cable connections. ______

G19. Doing maintenance work not directly assigned but that you determine must be performed. ______

G20. Replacing tools, test equipment and materials when work is finished. ______

G21. De-energizing (turning OFF) equipment when removing and replacing chassis and components. ______

G22. De-energizing equipment when connecting test equipment leads. ______

G23. Discharging capacitors when working with them in high voltage power supplies, regulators and transmitters. ______

G24. Properly grounding equipment before applying power. ______

G25. Keeping hands, arms and other parts of the body out of energized equipment. ______

G26. Not wearing hand jewelry and dangling necklaces, chains, etc. when working on energized equipment. ______

G27. Using the "one hand" rule when working with conductive materials. ______

G28. Keeping equipment components dry when working under inclement weather conditions. ______

G29. Not using water to put out electrical fires. ______

G30. Never working alone on energized equipment. ______

G31. Using appropriate safety devices and equipment (hooks, ropes, poles, rubber gloves, goggles, and first aid equipment) when called for. ______

G32. Immediately turning OFF power if electrical components become wet and arc. ______

G33. Not engaging in horseplay when performing maintenance on energized equipment. ______

G34. Not allowing test equipment leads, tools, wires, etc. to short circuit components. ______

G35. Inspecting switches and connector wires for serviceability (detecting bare wires, sparks, excessive heat). ______

G36. No cheating safety interlocks (except when reference procedures specifically call for this to be done). ______

G37. Wearing safety goggles and gloves when handling radioactive materials such as cathode ray tubes. ______

G38. Disposing of radioactive materials and glass tubes in the prescribed manner. ______

PART II - SPECIFIC SKILLS AND KNOWLEDGE.

For each item indicate whether or not you do what is described.

B1 Do you use the following terms in performing your MOS tasks?

	Yes	No
1. Voltage	____	____
2. Signal	____	____
3. Ground	____	____
4. Noise	____	____
5. Amplitude	____	____
6. Potential	____	____
7. Frequency	____	____
8. Bandwidth	____	____
9. Bandpass	____	____
10. Magnetism	____	____
11. Circuitry	____	____
12. Resistance	____	____
13. Impedance	____	____
14. Microwave	____	____
15. Parallax	____	____
16. Oscillation	____	____
17. Capacitance	____	____
18. Amplification	____	____
19. Power	____	____
20. Insulation	____	____
21. Conductance	____	____
22. Current	____	____

B2 Do you use or refer to the following electrical measurement units?

	Yes	No
1. Volts		
2. Amperes		
3. Ohms		
4. Herz		
5. Farads		
6. Watts		
7. Henries		

B3 Do you work with the following electrical circuits?

	Yes	No
1. AC circuits		
2. DC circuits		

B4 Do you work with the following vacuum tube circuits?

	Yes	No
1. Amplifier circuits		
2. Tuned (resonant) circuits		
3. Cathode follower circuits		
4. Multivibrator circuits		
5. Power supply circuits		
6. Voltage regulator circuits		
7. Oscillator circuits		
8. Sweep generator circuits		
9. Timing (pulse) circuits		
10. Display circuits		
11. Clamping (limiter) circuits		
12. Noise generator circuits		

B5 Do you work with the following solid state circuits? | Yes | No

		Yes	No
1.	AND-gate circuits		
2.	OR-gate circuits		
3.	NOR-gate circuits		
4.	NAND-gate circuits		
5.	Flip-flop circuits		
6.	Driver circuits		
7.	Adder circuits		
8.	Counter circuits		
9.	Input circuits		
10.	Output circuits		
11.	Coupler circuits		

B6 Do you work with the following microwave (RF) circuits?

		Yes	No
1.	Transmission line circuits (using waveguide)		
2.	Antenna circuits		
3.	Amplitude modulation circuits		
4.	Frequency modulation circuits		
5.	Pulse modulation circuits		
6.	Detector circuits		
7.	Frequency convertor circuits		
8.	Parallax circuits		

B7 Do you work with the following electrical items?

	Yes	No
1. Transmitters		
2. Receivers		
3. Cathode ray tubes		
4. Vacuum tubes		
5. Resistors		
6. Capacitors		
7. Circuit cards		
8. Diodes		
9. Transformers		
10. Relays		
11. Waveguides		
12. Antennas		
13. Electric motors		
14. Switches		
15. Fuses		
16. Lamps		
17. Connectors (plugs, jacks)		
18. Power cables		
19. Data cables		
20. Coaxial cables		

B8 Do you use the following test equipment?

	Item	Yes	No
1.	Oscilloscope		
2.	Electronic Voltmeter		
3.	TS-505 A/U multimeter		
4.	TS-505 B/U multimeter		
5.	TS-505 C/U multimeter		
6.	TS-505 D/U multimeter		
7.	Multimeter, but don't remember number designation		
8.	Stop watch		
9.	Tube adapter		
10.	Tube tester - TV-7		
11.	Digital volt meter		
12.	Wavemeter		
13.	Signal generator		
14.	Power measuring test set		
15.	Dummy load		

B9 Do you use the following High Frequency Console test equipment?

		Yes	No
1.	A multimeter		
2.	B multimeter		
3.	Dual purpose generator		
4.	Oscilloscope		
5.	Multifunction generator		
6.	Modulator oscillator		
7.	600 ohm attenuator		
8.	CW oscillator		
9.	Amplifier indicator		
10.	Thermal noise generator		
11.	Signal generator		
12.	50 mhz counter		

T10 Do you use the following tools in your maintenance duties?

	Yes	No
1. Screwdrivers - flat tip		
2. Screwdriver - cross tip (Phillips)		
3. Screwdriver - jewelers		
4. Hexagonhead wrenches (L bar, Allen)		
5. Open end wrenches		
6. Attenuator probes		
7. Jumper leads		
8. Rulers		
9. Pliers		
10. Wire strippers		
11. Pocket knife		
12. Torque wrench		
13. Soldering irons		
14. Soldering sets		
15. Soldering aids		
16. Heat sink		
17. Thickness gauge		
18. Dial indicators		
19. Non-magnetic tools		
20. Tuning wands		
21. RF probes		
22. Card extractors		

M11 Do you use or work with the following mechanical items? Yes No

1. Gaskets
2. Nuts
3. Bolts
4. Index (locking) pins in gear assemblies.
5. Screws
6. Retaining clamps
7. Set screws
8. BNC/BSM/TEE connectors
9. Clamps
10. Wire
11. Dessicants
12. Filters (air and liquid)
13. Coolant fluids
14. Lubricants
15. Gears
16. Gear trains
17. Synchros
18. Pumps - fluid
19. Air compressors
20. Pressure gauges - fluid
21. Pressure gauges - air
22. Resolvers

*MC12 Do you use or refer to the following mathematical and measurement concepts?

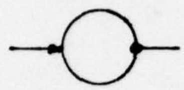
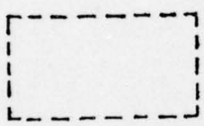
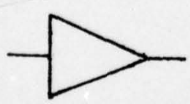
	Yes	No
1. Ratio		
2. Percentage (%)		
3. Positive (+)/Negative (-) values		
4. Symbols indicating arithmetic operations:		
1. + denotes add		
2. - denotes subtract		
3. x denotes multiply		
4. ÷ denotes divide		
5. = denotes equals		
6. ± denotes plus or minus		
5. Symbols representing powers of ten:		
1. uu micro micro		
2. n nano		
3. u micro		
4. m milli		
5. K Kilo		
6. M Mega		
7. G Giga		
6. Square root of a number		
7. Square of a number		
8. Algebra equations (example: $3A^2 + 5B - C = X$)		
9. Basic geometry:		
1. Radius of a circle		

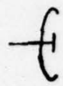
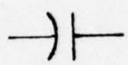
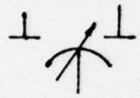
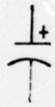
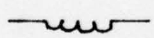
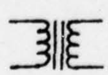
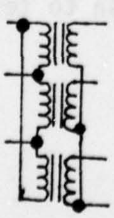
	Yes	No
2. Degrees in a circle	____	____
3. Minutes in a degree	____	____
4. Perimeter of a circle	____	____
5. Intersect	____	____
6. Rectangle	____	____
7. Vertical	____	____
8. Horizontal	____	____
9. Right triangle	____	____
10. Torque values (inch or foot pounds)	____	____
11. Maximum/minimum	____	____
12. Scales or graphs	____	____
13. Time measurement:		
1. Minutes/seconds	____	____
2. Micro - seconds	____	____
3. Milli - seconds	____	____
4. Nano - seconds	____	____
14. Numbering systems:		
1. Binary	____	____
2. Octal	____	____
3. Hexadecimal	____	____
15. Boolean algebra	____	____
16. Logic diagrams	____	____
17. Truth tables	____	____
18. Parallax theory	____	____
19. Rank order (preferential selection)	____	____

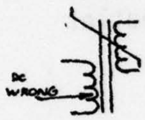
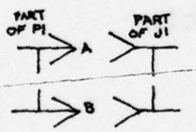
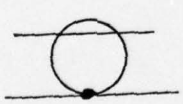
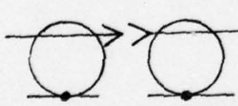
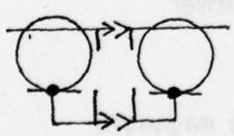
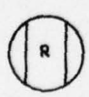
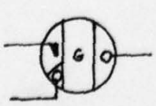
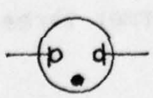
SC-13 Do you use, refer to or read the following electronic symbols and designations?

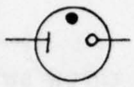
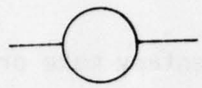
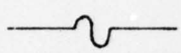
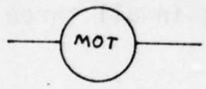
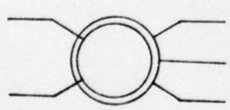
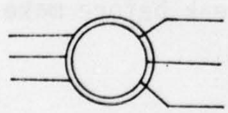
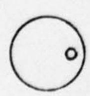
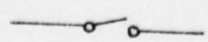
			Yes	No
1.	P	Power measured in watts.		
2.	E	Voltage		
3.	ac	Alternating current		
4.	dc	Direct current		
5.	I	Current measured in amperes.		
6.	R	Resistance measured in ohms.		
7.	C	Capacitance measured in farads.		
8.	L	Inductance measured in henries.		
9.	db	Decibels		
10.	Ø	Phase		
11.	RF	Radio frequency		

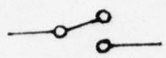
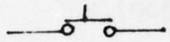
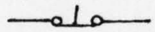
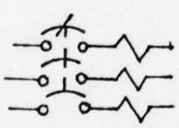
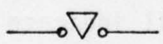
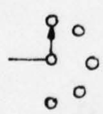
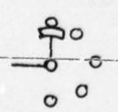
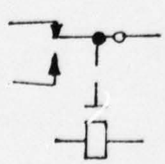
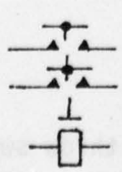
SC-14 Do you use and refer to the following schematic symbols?

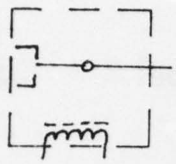
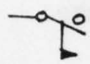
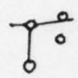
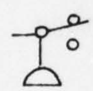
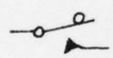
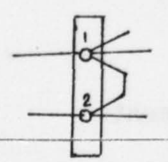
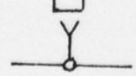
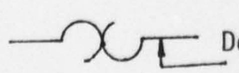
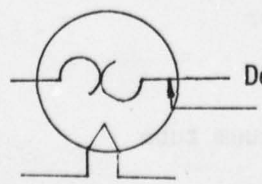
			Yes	No
1.		Denotes that component is adjustable	____	____
2.		Denotes slip ring	____	____
3.		Denotes buildup for variable resistors	____	____
4.		Denotes mechanical linkage or shielding	____	____
5.		Denotes general enclosure of functional grouping	____	____
6.		Denotes minor signal, arrow points in direction of signal flow	____	____
7.		Denotes major signal, arrow points in direction of signal flow	____	____
8.		Denotes amplifier	____	____
9.		Denotes system ground	____	____
10.		Denotes chassis ground	____	____
11.		Denotes common connector	____	____
12.		Denotes loudspeaker	____	____

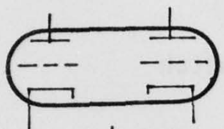
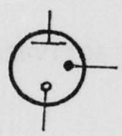
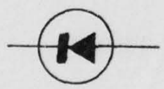
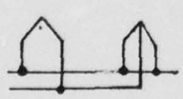
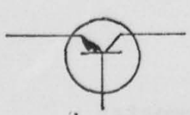
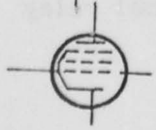
			Yes	No
13.		Denotes antenna or horn		
14.		Denotes parabolic antenna		
15.		Denotes female convenience outlet		
16.		Denotes capacitor		
17.		Denotes variable differential capacitor		
18.		Denotes electrolytic capacitor		
19.		Denotes coil		
20.		Denotes choke		
21.		Denotes air core transformer		
22.		Denotes transformer with magnetic core and electrostatic shield		
23.		Denotes iron core transformer		
24.		Denotes iron core transformer three phase delta to wye.		

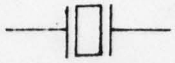
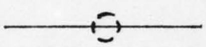
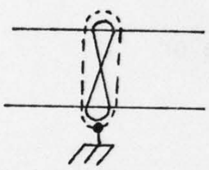
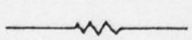
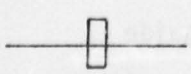
			Yes	No
25.		Denotes adjustable transformer		
26.		Denotes auto transformer		
27.		Denotes saturable reactor		
28.		Denotes female feed through connector		
29.		Denotes male-female connectors		
30.		Denotes mated connectors		
31.		Denotes coaxial connector		
32.		Denotes mated coaxial connectors		
33.		Denotes mated coaxial, outside connectors shown carried through		
34.		Denotes pilot lamp (letter indicates color)		
35.		Denotes pilot lamp with push to test		
36.		Denotes AC neon lamp		

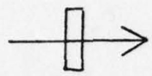
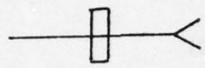
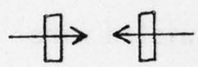
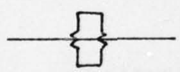
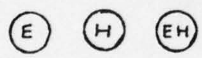
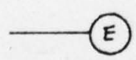
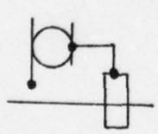
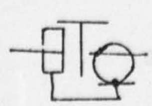
			Yes	No
37.		Denotes DC neon lamp		
38.		Denotes instrument meter (letter placed in center to indicate function).		
39.		Denotes fuse		
40.		Denotes generator		
41.		Denotes motor		
42.		Denotes synchro (letter will indicate type of device).		
43.		Denotes synchro, transmitter, receiver, or control transformer		
44.		Denotes synchro, differential transmitter or receiver		
45.		Denotes a handwheel		
46.		Denotes cams		
47.		Denotes limit cam		
48.		Denotes single pole single throw switch		

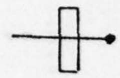
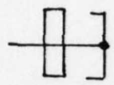
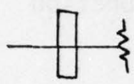
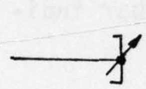
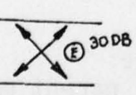
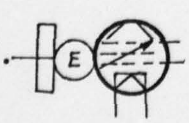
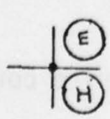
			Yes	No
49.		Denotes single pole double throw switch	______	______
50.		Denotes push-button momentary make or spring return	______	______
51.		Denotes push-button momentary break or spring return	______	______
52.		Denotes three pole switch breaker with magnetic overload device in all three poles.	______	______
53.		Denotes interlock	______	______
54.		Denotes circuit breaker	______	______
55.		Denotes rotary switch break before make	______	______
56.		Denotes rotary switch make before break	______	______
57.		Denotes relay (de-energized)	______	______
58.		Denotes contactor relay (de-energized)	______	______

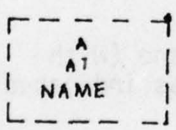
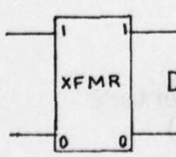
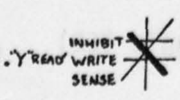
			Yes	No
59.		Denotes chopper relay		
60.		Denotes flow activate switch		
61.		Denotes liquid level activate switch		
62.		Denotes pressure or vacuum activate switch		
63.		Denotes transfer switch		
64.		Denotes thermal time delay relay		
65.		Denotes single terminal		
66.		Denotes shielded terminal		
67.		Denotes terminal board		
68.		Denotes test jack		
69.		Denotes break contact thermostat		
70.		Denotes break contact thermal relay		

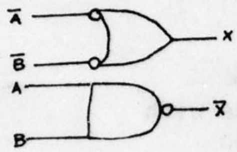
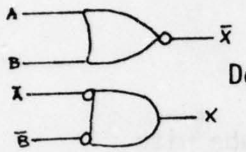
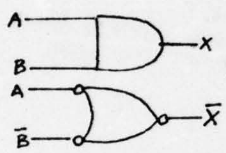
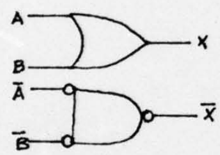
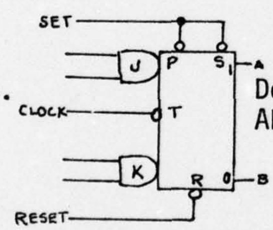
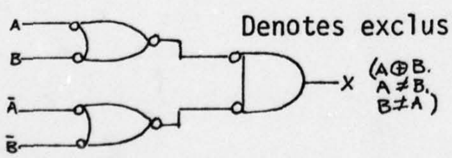
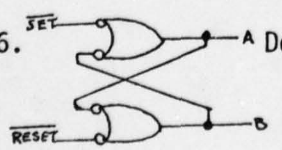
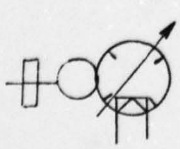
			Yes	No
71.		Denotes triode vacuum tube		
72.		Denotes dual triode vacuum tube		
73.		Denotes a thyratron vacuum tube		
74.		Denotes a vacuum tube dc voltage regulator		
75.		Denotes crystal diode		
76.		Denotes breakdown diode (Zener)		
77.		Denotes bi-polar voltage limiter, surge suppressor		
78.		Denotes vacuum tube diode		
79.		Denotes vacuum tube filaments (single and double)		
80.		Denotes NPN transistor		
81.		Denotes PNP transistor		
82.		Denotes a pentode vacuum tube		

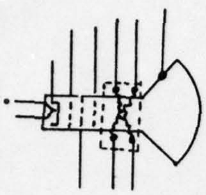
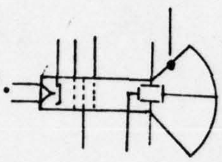
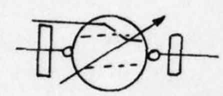
			Yes	No
83.		Denotes a crystal	____	____
84.		Denotes single conductor	____	____
85.		Denotes shielded conductor	____	____
86.		Denotes shielded double twisted wire	____	____
87.		Denotes common shield (separated for convenience of illustration).	____	____
88.		Denotes connected conductors	____	____
89.		Denotes conductors not connected	____	____
90.		Denotes resistor	____	____
91.		Denotes thermistor	____	____
92.		Denotes symmetrical varistor	____	____
93.		Denotes circular waveguide	____	____
94.		Denotes rectangular waveguide	____	____

			Yes	No
95.		Denotes coaxial waveguide		
96.		Denotes plain flange		
97.		Denotes choke flange		
98.		Denotes mated plain flange or rectangular waveguide		
99.		Denotes flexing waveguide		
100.		Denotes waveguide coupling by aperture (letter inside circle indicates plane)		
101.		Denotes aperture to space		
102.		Denotes probe to space		
103.		Denotes probe coaxial to rectangular waveguide		
104.		Denotes loop to space		
105.		Denotes mode transducer		
106.		Denotes rectangular waveguide transducer to coaxial		

			Yes	No
107.		Denotes waveguide shims		
108.		Denotes short termination		
109.		Denotes resistor termination		
110.		Denotes variable termination short		
111.		Denotes open circuit		
112.		Denotes single cavity resonator		
113.		Denotes fixed waveguide attenuator		
114.		Denotes variable waveguide attenuator		
115.		Denotes coupling by E plane (with aperture transmission loss indicated)		
116.		Denotes mechanical tuned cavity resonator		
117.		Denotes reflex klystron aperture coupled (adjustable cavity)		
118.		Denotes Hybrid junction (Magic TEE)		

			Yes	No
119.	•	Denotes the AND function		
120.	+	Denotes the OR function		
121.	$\oplus$	Denotes the exclusive OR function		
122.	$\overline{\text{NAME}}$	Denotes the superscript bar indicating the NOT function		
123.	$\cong$	Denotes approximate equality		
124.	$\equiv$	Denotes an equivalence		
125.	NAME´	Denotes prime which indicates a difference in delay between two signals		
126.	o	Denotes a normally low signal state		
127.		Denotes a module enclosure: A. indicates location of parent module A1 indicates Module reference designation and parent plate plug number Module name - describes functional use of module.		
128.		Denotes a transformer		
129.		Denotes a read/write memory ferrite core		

		Yes	No
130. 	Denotes a NAND Gate	____	____
131. 	Denotes a NOR Gate	____	____
132. 	Denotes an AND Gate	____	____
133. 	Denotes an OR Gate	____	____
134. 	Denotes JK Flip Flop with an AND input	____	____
135. 	Denotes exclusive OR Gates	____	____
136. 	Denotes a R-S Flip-Flop (Latch)	____	____
137. 	Denotes a tunable magnetron, aperture coupled.	____	____

			Yes	No
138.		Denotes cathode ray tube with electrostatic deflection		
139.		Denotes cathode ray tube with electromagnetic deflection		
140.		Denotes TR tube		

SC15 Schematic reference designators:

			Yes	No
1.	ØA	Designates A phase	____	____
2.	ØB	Designates B phase	____	____
3.	ØC	Designates C phase	____	____
4.	B^+	Designates plate voltage to a vacuum tube	____	____
5.	B	Designates a motor, synchro or resolver	____	____
6.	b	Designates the base of a transistor	____	____
7.	C	Designates a capacitor	____	____
8.	c	Designates the cathode of a tube or the collector of a transistor	____	____
9.	CW	Designates clockwise direction	____	____
10.	ccw	Designates counter clockwise direction	____	____
11.	CR	Designates a crystal rectifier - crystal diode	____	____
12.	crt	Designates a cathode ray tube	____	____
13.	DS	Designates a lamp or light	____	____
14.	del	Designates a delay	____	____
15.	e	Designates the emitter of a transistor	____	____
16.	fil	Designates filament voltage	____	____

			Yes	No
17.	F	Designates a fuse	____	____
18.	g	Designates the grid of a vacuum tube	____	____
19.	Gnd	Designates ground	____	____
20.	Hz	Designates Herz (cycles per second)	____	____
21.	J	Designates a jack	____	____
22.	K	Designates a relay	____	____
23.	L	Designates a coil	____	____
24.	k	Designates the cathode of a diode	____	____
25.	M	Designates a meter, or motor	____	____
26.	MG	Designates a motor generator	____	____
27.	NU	Designates a nominal value	____	____
28.	PRF	Designates pulses repetition frequency	____	____
29.	P	Designates a plug	____	____
30.	pps	Designates pulses per second	____	____
31.	P	Designates plate of a vacuum tube	____	____
32.	Q	Designates a transistor	____	____
33.	R	Designates a resistor	____	____

			Yes	No
34.	rpm	Designates revolutions per minute	_____	_____
35.	RTN	Designates a return	_____	_____
36.	S	Designates a switch	_____	_____
37.	SB	Designates a slow blow fuse	_____	_____
38.	T	Designates a transformer	_____	_____
39.	TB	Designates a terminal board	_____	_____
40.	vdc	Designates direct current voltage	_____	_____
41.	vac	Designates alternating current voltage	_____	_____
42.	V	Designates a vacuum tube	_____	_____
43.	W	Designates a wire	_____	_____
44.	w	Designates watts	_____	_____
45.	X	Designates horizontal axis on a cathode ray tube	_____	_____
46.	Y	Designates vertical axis on a cathode ray tube	_____	_____

B16 Do you perform the following general maintenance procedures?

	Yes	No
1. Electrical alinement	____	____
2. Electrically ground equipment	____	____
3. Insulate equipment	____	____
4. Make adjustments for a null indication	____	____
5. Make adjustments until a signal indication is obtained	____	____
6. Inspect electronic equipment for physical damage, moisture and contaminants	____	____
7. Locate the physical position of chassis	____	____
8. Locate the physical position of components on a chassis	____	____
9. Locate test points on equipment	____	____
10. Locate ground points on equipment	____	____
11. Adjust controls to obtain proper indications	____	____
12. Select the appropriate technical manual, field manual, supply manual, etc., as references for maintenance procedures and information	____	____
13. Use flow charts	____	____

I17 Does your job require that you obtain or use information in the following ways?

	Yes	No
1. Look for information indicating normal operating conditions.		
2. Look for information indicating non-normal operating conditions.		
3. Relate information you obtain from schematic diagrams to operational equipment.		
4. Relate information you obtain from block diagrams to operational equipment.		
5. Relate information you obtain from wiring diagrams to operational equipment.		
6. Relate information you obtain from the description of procedures in a written document to operational equipment.		
7. Interpret information you obtain from the use of test equipment.		
8. Make decisions about what your next action will be based upon your interpretation of information.		
9. Discriminate between signal and noise information.		

TH18 Do you refer to or apply the following theory information in your maintenance work?

		Yes	No
1.	How a radar transmitter works. (operational functioning)	____	____
2.	Why a radar transmitter works. (radio frequency RF theory)	____	____
3.	How a radar receiver works (operational functioning).	____	____
4.	Why a radar receiver works (radio frequency theory)	____	____
5.	Problems created by magnetism when reading meters or adjusting resonant circuits, caused by the interaction of magnetic materials (iron, steel, etc.) with electrical fields.	____	____
6.	Insulative value of common materials.	____	____
7.	Conductive value of common materials.	____	____
8.	Ohm's law.	____	____
9.	How a vacuum tube works.	____	____
10.	Why a vacuum tube works.	____	____
11.	The resistance that devices or materials offer to the flow of current.	____	____
12.	The capacity of a device for storing electricity.	____	____
13.	How a transistor works.	____	____
14.	Why a transistor works.	____	____
15.	How a diode works.	____	____
16.	Why a diode works.	____	____
17.	How a transformer works.	____	____
18.	Why a transformer works (magnetic induction theory).	____	____
19.	How a relay works.	____	____
20.	Why a relay works (electromagnetic or thermal theory).	____	____

	Yes	No
21. How an electric motor works.		
22. Why an electric motor works (magnetic field theory).		
23. How an air compressor works.		
24. How a pump works.		
25. How an antenna works.		
26. Why an antenna works (RF transmission theory).		

EE19 If you work with transmitters do you do the following? (If you do not work with transmitters go to item EE20).

	Yes	No
1. Inspect them.		
2. Remove/replace them.		
3. Repair them.		
4. Check (test) operation of them.		
5. Service them.		
6. Troubleshoot (diagnose) them.		
7. Adjust them.		

EE20 If you work with receivers do you do the following? (If not go to EE21)

1. Inspect them.		
2. Remove/replace them.		
3. Repair them.		
4. Check (test) operation of them.		
5. Service them.		
6. Troubleshoot (diagnose) them.		
7. Adjust them.		

EE21 If you work with electric motors do you do the following? (If not go to EE22).

1. Inspect them.		
2. Remove/replace them.		
3. Repair them.		
4. Check (test) operation of them.		

	Yes	No
5. Service them.		
6. Troubleshoot (diagnose) them.		
7. Adjust them.		

EC22 If you work with cathode ray tubes do you do the following? (If not, go on to EC23)

	Yes	No
1. Inspect them.	____	____
2. Remove/replace them.	____	____
3. Check (test) operation of them.	____	____
4. Adjust them.	____	____

EC23 If you work with vacuum tubes do you do the following? (If not, go on to EC24)

1. Inspect them.	____	____
2. Remove/replace them.	____	____
3. Check (test) operation of them.	____	____

EC24 If you work with resistors do you do the following? (If not, go on to EC25).

1. Inspect them.	____	____
2. Remove/replace them.	____	____
3. Check (test) operation of them.	____	____
4. Select them by color code.	____	____

EC25 If you work with capacitors do you do the following? (If not, go on to EC26).

1. Inspect them.	____	____
2. Remove/replace them.	____	____
3. Check (test) operation of them.	____	____
4. Select them by color code.	____	____

		Yes	No
EC26	If you work with diodes do you do the following? (If not, go on to EC27).		
	1. Inspect them.	___	___
	2. Remove them.	___	___
	3. Check (test) operation of them.	___	___
EC27	If you work with transformers do you do the following? (If not, go on to EC28).		
	1. Inspect them.	___	___
	2. Remove/replace them.	___	___
	3. Check (test) operation of them.	___	___
EC28	If you work with relays do you do the following? (If not, go on to EC29).		
	1. Inspect them.	___	___
	2. Remove/replace them.	___	___
	3. Check (test) operation of them.	___	___
EC29	If you work with circuit cards, do you do the following? (If not, go on to EC30).		
	1. Inspect them.	___	___
	2. Remove/replace them.	___	___
	3. Check (test) operation of them.	___	___
	4. Repair them.	___	___

EC30 If you work with switches do you do the following? (If not, go on to EC31).

	Yes	No
1. Inspect them.		
2. Remove/replace them.		
3. Check (test) operation of them.		

EC31 If you work with fuses do you do the following? (If not, go on to EC32).

1. Inspect them.		
2. Remove/replace them.		
3. Check (test) operation of them.		

EC32 If you work with lamps do you do the following? (If not, go on to EC33).

1. Inspect them.		
2. Remove/replace them.		
3. Check (test) operation of them.		

EC33 If you work with connectors (plugs, jacks) do you do the following? (If not, go on to EC34).

1. Inspect them.		
2. Remove/replace them.		
3. Check (test) operation of them.		
4. Repair them.		

		Yes	No
EC34	If you work with power cables do you do the following? (If not, go on to EC35).		
	1. Inspect them.	____	____
	2. Remove/replace them.	____	____
	3. Check (test) operation of them.	____	____
	4. Repair them.	____	____
	5. Fabricate them.	____	____
EC35	If you work with data cables do you do the following? (If not, go on to EC36).		
	1. Inspect them.	____	____
	2. Remove/replace them.	____	____
	3. Check (test) operation of them.	____	____
	4. Repair them.	____	____
	5. Fabricate them.	____	____
EC36	If you work with coaxial cables do you do the following?		
	1. Inspect them.	____	____
	2. Remove/replace them.	____	____
	3. Check (test) operation of them.	____	____
	4. Repair them.	____	____
	5. Fabricate them.	____	____

Background Data

MOS ________ Date ________

Name ________________ (Last, first, middle initial) Rank ________ Age ______

Unit ________________ Time in present duty position ______ (months)

Total time on active duty ______ (months) Total time working in electronics ______ (months)

General Education: (circle highest year of school completed).

9, 10, 11, 12 High School Graduate
13, 14, Associates Degree ____________ (list specialty)
15, 16, Bachelors Degree ____________ (major)

Additional Degrees

MOS INFORMATION

	MOS	Months Held	How Awarded: School	How Awarded: OJT	How Awarded: Transition	Highest Rank Held
Primary	____	____	____	____	____	____
Duty	____	____	____	____	____	____
Additional or Former Electronic MOS(s)	____	____	____	____	____	____
	____	____	____	____	____	____
	____	____	____	____	____	____

ELECTRONIC TRAINING - MILITARY

Army:	Year attended	MOS awarded	Length of course (weeks)
US Army Air Defense School			
US Army Missile and Munitions School			
Other US Army Schools (school name)			

Army Correspondence Schools:

Name of Course	School	Year Completed	Credit Hours

Other US Service Schools:

Course Title	School	Year Completed	Credit Hours

ELECTRONIC TRAINING - MILITARY (continued)

Contractor Operated Schools (New Equipment Training):

Course Title	System	Year Completed	Course length (weeks)

Did you attend COBET? ______ Yes ______ No

Where ____________ When ____________ Course length ____________

ELECTRONIC TRAINING - CIVILIAN

High School (school name)	Course Title	Course length (weeks)	Year Completed

College:

Other Civilian Schools:

Industry Training
(corporation name)

ELECTRONIC WORK EXPERIENCE

Military:

Assigned Unit	Duty MOS	Months Assigned	Highest Rank	Location (US, Germany Korea, etc.)	Position Title (Repairman, Section Chief, Platoon Leader, CO, etc.)
Battery					
Direct Support					
General Support					
Depot					
At Service Schools: (Name of school)					
Other Units (list units)					

ELECTRONIC WORK EXPERIENCE (continued)

<u>Civilian</u>:

Position Title (Check those applicable)		Time Worked (in months)	Type of work performed. Briefly describe main duties, i.e.: fixed radios, assemble TV's, installed telephones, etc.)
Electronic:			
Technician	______	______	______
Repairman	______	______	______
Installer	______	______	______
Tester	______	______	______
Fabricator	______	______	______
Assembler	______	______	______
Designer	______	______	______
Other:			
______	______	______	______
______	______	______	______

Appendix E

Questionnaire Response Data

The means of field response to importance of General Work Habits and Safe Operating Procedures.

Statement Number	MOS 24E	24J	24H	Combined	Statement Number	MOS 24E	24J	24H	Combined
G-1	8.9	8.3	8.6	8.64	G-14	9.5	8.5	9.1	9.10
G-2	9.6	8.9	8.4	9.08	G-15	9.2	8.6	9.6	9.18
G-3	9.0	9.0	9.0	9.02	G-16	8.6	7.9	8.2	8.30
G-4	8.9	8.9	8.8	8.90	G-17	8.3	8.6	7.8	8.28
G-5	8.8	8.2	8.8	8.66	G-18	8.8	8.6	8.6	8.68
G-6	9.2	9.0	9.2	9.18	G-19	8.3	7.5	6.8	7.62
G-7	8.7	8.4	8.8	8.66	G-20	9.0	7.9	7.7	8.28
G-8	8.8	8.4	8.7	8.68	G-21	6.8	8.1	9.1	7.86
G-9	8.9	8.2	8.0	8.46	G-22	4.5	7.6	6.5	6.04
G-10	6.5	6.6	7.4	6.82	G-23	9.6	9.6	9.3	9.50
G-11	8.9	8.4	8.6	8.68	G-24	9.8	9.7	9.9	9.82
G-12	8.9	7.8	7.0	8.00	G-25	8.4	8.5	9.2	8.70
G-13	9.0	8.3	7.5	8.36	G-26	8.8	8.4	9.0	8.74

The means of field response to importance of General Work Habits and Safe Operating Procedures.

Statement Number	MOS			
	24E	24J	24H	Combined
G-27	8.2	8.1	7.9	8.08
G-28	9.5	9.0	9.6	9.38
G-29	9.9	8.7	9.3	9.34
G-30	7.0	7.9	8.3	7.68
G-31	9.0	7.9	7.9	8.34
G-32	9.3	9.5	9.9	9.56
G-33	9.7	9.3	9.9	9.62
G-34	9.8	9.3	9.4	9.56
G-35	9.6	8.5	8.3	8.90
G-36	7.2	7.5	7.3	7.34
G-37	7.0	7.7	7.4	7.34
G-38	8.0	8.0	7.5	7.86

The percentage of respondee's performing described tasks.

Task Number	MOS 24E	MOS 24J	MOS 24H	Combined	Task Number	MOS 24E	MOS 24J	MOS 24H	Combined
B1									
1	100	100	100	100	15	95	93	46	80
2	100	100	100	100	16	100	100	100	100
3	100	100	100	100	17	85	100	100	94
4	100	100	100	100	18	100	100	100	100
5	95	100	100	98	19	100	100	86	96
6	65	100	93	84	20	100	93	100	98
7	100	100	100	100	21	85	93	100	92
8	80	100	80	86	22	100	100	100	100
9	40	93	80	68	B2				
10	80	86	60	76	1	100	100	100	100
11	90	100	100	96	2	95	93	86	92
12	90	100	100	96	3	100	100	100	100
13	75	93	100	88	4	80	100	100	92
14	60	73	33	56	5	55	100	93	80

Task Number	MOS 24E	24J	24H	Combined
B2				
6	90	93	86	90
7	40	86	93	70
B3				
1	95	100	100	98
2	100	100	100	100
B4				
1	100	100	100	100
2	95	93	86	92
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	95	100	100	98
7	100	100	93	98
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	100	100	100	100

Task Number	24E	24J	24H	Combined
12	100	100	86	96
B5				
1	65	40	100	68
2	65	40	100	68
3	55	40	100	64
4	65	40	100	68
5	80	60	100	80
6	70	73	100	80
7	40	66	100	66
8	65	86	100	82
9	90	93	100	94
10	90	93	100	94
11	90	100	100	96
B6				
1	95	86	26	72
2	95	93	33	76
3	80	93	46	74

Task Number	MOS 24E	24J	24H	Combined
4	85	86	60	79
5	100	93	53	84
6	90	86	60	80
7	80	93	60	78
8	100	86	40	78
B7				
1	100	100	40	82
2	100	100	40	82
3	95	100	93	96
4	100	100	100	100
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	100	100	26	78

Task Number	24E	24J	24H	Combined
12	100	100	26	78
13	100	100	86	96
14	100	100	100	100
15	100	100	100	100
16	100	100	100	100
17	100	100	100	100
18	100	100	100	100
19	100	100	100	100
20	100	100	100	100
B8				
1	100	100	100	100
2	85	100	93	92
3	60	60	46	56
4	40	53	13	36
5	45	53	6	36
6	55	60	13	44
7	85	66	86	80

Task Number	MOS 24E	24J	24H	Combined	Task Number	24E	24J	24H	Combined
B8									
8	50	86	46	60	8	0	100	80	54
9	90	100	93	94	9	10	100	86	60
10	100	86	66	86	10	5	93	80	54
11	100	100	100	100	11	65	100	93	84
12	80	93	67	62	12	20	100	100	68
13	100	100	93	98					
14	95	100	46	82					
15	75	100	73	82					
B9									
1	5	100	100	62					
2	0	100	100	60					
3	10	100	93	62					
4	50	100	100	60					
5	10	100	93	62					
6	0	100	86	56					
7	15	100	86	62					

Task Number	24E	24J	24H	Combined	Task Number	24E	24J	24H	Combined
		MOS							
T10									
1	100	100	100	100	17	40	40	26	36
2	100	100	100	100	18	50	60	26	46
3	100	100	100	100	19	100	66	66	80
4	100	93	86	94	20	95	86	66	84
5	95	93	100	96	21	60	100	66	74
6	95	100	100	98	22	40	93	100	74
7	95	100	93	96					
8	50	60	53	54					
9	100	100	100	100					
10	95	100	93	96					
11	95	100	93	96					
12	60	40	40	48					
13	100	100	100	100					
14	100	100	86	96					
15	100	100	93	98					
16	80	100	100	92					

Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined	Task Number	24E	24J	24H	Combined
M11									
1	95	73	40	72	17	100	100	100	100
2	100	93	100	98	18	90	80	100	68
3	100	93	100	98	19	100	80	26	76
4	85	66	100	80	20	100	93	40	76
5	100	93	100	98	21	100	86	26	74
6	100	86	100	96	22	90	86	26	92
7	95	93	100	92					
8	80	100	100	92					
9	100	100	100	94					
10	95	93	100	96					
11	100	100	33	80					
12	100	86	80	90					
13	100	93	33	78					
14	100	80	66	84					
15	100	86	93	94					
16	95	86	86	90					

Task Number	MOS 24E	24J	24H	Combined
MC12				
1	60	93	100	76
2	75	93	80	80
3	100	100	100	100
4				
1	75	100	80	84
2	75	100	80	84
3	65	100	80	80
4	65	93	80	78
5	70	100	80	82
6	80	100	80	86
5				
1	55	86	80	72
2	50	73	93	70
3	90	100	100	96
4	85	100	100	94

Task Number	MOS 24E	24J	24H	Combined
5	95	100	93	96
6	85	100	100	94
7	65	80	46	64
6	25	33	53	36
7	30	33	46	36
8	15	26	60	32
9				
1	50	33	46	44
2	60	60	80	66
3	30	33	26	30
4	40	26	40	36
5	50	46	40	46
6	35	20	40	32
7	85	80	80	82
8	85	80	80	82

Task Number		MOS			
		24E	24J	24H	Combined
MC12					
9					
	9	35	53	66	50
10		60	46	26	46
11		95	100	93	96
12		75	86	66	76
13					
	1	90	100	93	94
	2	65	100	100	86
	3	70	100	100	88
	4	30	86	93	66
14					
	1	45	53	100	64
	2	45	53	100	64
	3	25	20	93	44
15		30	20	73	40

Task Number	24E	24J	24H	Combined
16	50	46	100	64
17	35	46	100	58
18	55	80	26	54
19	40	40	26	36

Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined	Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined
SC-13									
1	90	100	80	90	4	95	93	93	94
2	95	100	100	98	5	95	100	93	96
3	95	100	100	98	6	95	100	93	96
4	90	100	100	98	7	95	100	100	98
5	95	100	100	96	8	95	100	100	98
6	85	100	100	98	9	100	100	100	100
7	65	100	100	94	10	100	93	100	98
8	95	93	93	82	11	70	86	73	76
9	95	93	80	90	12	95	73	73	82
10	95	100	100	98	13	90	100	53	82
11	95	100	80	92	14	85	93	20	68
SC-14					15	100	100	80	94
1	95	100	100	98	16	95	100	100	98
2	100	93	26	76	17	90	93	60	82
3	85	100	100	94	18	85	93	80	86

Task Number	MOS				Task Number	MOS			
	24E	24J	24H	Combined		24E	24J	24H	Combined
SC-14									
19	100	100	100	100	34	95	100	93	96
20	100	100	66	90	35	85	80	73	80
21	100	100	100	100	36	100	93	86	94
22	75	80	86	80	37	85	93	80	86
23	100	100	93	98	38	95	86	93	92
24	80	86	60	76	39	100	100	100	100
25	80	66	73	74	40	90	100	73	88
26	70	86	60	72	41	95	100	93	96
27	40	60	13	38	42	90	100	73	88
28	85	100	86	90	43	95	100	100	98
29	95	100	93	96	44	100	100	100	100
30	95	100	100	98	45	100	100	86	96
31	90	100	86	92	46	100	93	66	88
32	95	100	93	96	47	80	86	40	70
33	95	100	93	96	48	100	100	100	100

Task Number	MOS				Task Number	MOS			
	24E	24J	24H	Combined		24E	24J	24H	Combined
SC-14									
49	95	100	100	98	64	65	93	87	80
50	95	100	100	98	65	100	100	100	100
51	100	100	100	100	66	100	100	100	100
52	65	93	86	80	67	85	100	93	92
53	100	100	100	100	68	85	93	67	82
54	100	100	100	100	69	100	100	100	100
55	85	100	93	92	70	100	100	100	100
56	100	93	66	82	71	100	100	100	100
57	100	100	100	100	72	100	100	100	100
58	100	100	100	100	73	100	100	80	94
59	80	87	40	70	74	95	93	93	94
60	100	100	100	100	75	100	100	100	100
61	95	100	100	98	76	100	100	100	100
62	95	100	100	98	77	95	93	80	90
63	100	100	100	100	78	95	93	93	94

Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined	Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined
SC-14									
79	100	100	100	100	94	80	100	13	66
80	85	100	100	94	95	75	86	33	66
81	85	100	100	94	96	50	73	13	46
82	85	100	100	94	97	50	66	13	44
83	85	100	60	82	98	55	73	13	48
84	85	100	86	90	99	60	80	6	50
85	90	100	93	94	100	35	40	6	28
86	90	100	100	96	101	40	53	13	36
87	90	93	73	86	102	55	46	13	40
88	80	93	86	86	103	55	66	6	44
89	80	93	86	86	104	50	60	6	40
90	90	100	100	96	105	50	53	6	38
91	80	93	86	86	106	50	53	6	38
92	70	73	26	58	107	30	73	6	36
93	65	66	13	50	108	25	60	6	30

Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined	Task Number	MOS 24E	MOS 24J	MOS 24H	MOS Combined
SC-14									
109	55	66	13	46	124	65	60	53	60
110	45	40	6	32	125	30	26	66	40
111	75	86	33	66	126	35	33	66	44
112	55	73	13	48	127	56	86	86	74
113	75	80	13	50	128	65	80	86	76
114	60	80	13	52	129	25	20	100	46
115	50	26	6	30	130	20	33	100	68
116	65	73	20	54	131	70	33	100	68
117	65	60	26	52	132	70	33	100	68
118	40	40	6	30	133	70	33	100	68
119	60	40	100	66	134	60	33	100	64
120	60	40	100	66	135	60	33	100	64
121	55	33	100	62	136	45	33	100	58
122	30	20	86	44	137	65	46	13	44
123	70	53	73	60	138	90	80	86	86

Task Number	MOS			
	24E	24J	24H	Combined
SC-14				
139	95	86	100	94
140	85	86	20	66

Task Number	MOS				Task Number	MOS			
	24E	24J	24H	Combined		24E	24J	24H	Combined
SC-15									
1	100	100	100	100	16	100	100	100	100
2	100	100	100	100	17	100	100	100	100
3	100	100	100	100	18	100	100	93	98
4	100	100	100	100	19	100	100	100	100
5	85	100	93	92	20	100	100	100	100
6	90	93	100	94	21	95	100	93	96
7	90	93	100	94	22	95	100	93	96
8	95	93	86	92	23	100	100	100	100
9	100	100	100	100	24	90	100	86	92
10	100	100	100	100	25	100	100	100	100
11	100	93	86	94	26	95	100	86	94
12	100	100	100	100	27	55	100	46	66
13	100	93	100	98	28	95	100	100	98
14	90	93	93	92	29	100	100	93	98
15	100	100	100	100	30	95	100	93	96

Task Number	MOS				Task Number	MOS			
	24E	24J	24H	Combined		24E	24J	24H	Combined
SC-15									
31	95	100	80	92	46	95	100	100	98
32	90	100	100	96					
33	95	100	93	96					
34	95	100	100	98					
35	95	100	93	96					
36	95	100	100	98					
37	95	100	86	94					
38	95	100	100	98					
39	100	100	93	98					
40	95	100	100	98					
41	95	100	100	98					
42	95	100	86	94					
43	90	86	60	80					
44	100	100	93	98					
45	95	100	100	98					

Task Number	MOS			
	24E	24J	24H	Combined
B16				
1	100	100	100	100
2	100	100	93	98
3	90	100	86	86
4	100	80	86	96
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100
8	95	100	100	98
9	100	100	100	100
10	100	100	100	100
11	100	100	100	100
12	100	100	100	100
13	45	100	73	62

Task Number	MOS			
	24E	24J	24H	Combined
I17				
1	100	73	100	98
2	95	93	93	94
3	100	100	100	100
4	90	100	93	94
5	100	100	93	98
6	90	100	100	96
7	100	100	93	98
8	100	100	93	98
9	95	93	100	96

Task Number	MOS 24E	MOS 24J	MOS 24H	Combined	Task Number	MOS 24E	MOS 24J	MOS 24H	Combined
TH18									
1	90	100	26	74	16	70	80	73	74
2	85	73	26	64	17	95	100	93	96
3	90	100	20	72	18	75	73	66	72
4	85	73	20	62	19	95	100	93	96
5	80	86	46	72	20	75	80	66	74
6	70	53	53	60	21	100	93	80	92
7	75	73	53	68	22	80	73	60	72
8	90	93	93	92	23	90	86	33	72
9	85	100	93	92	24	85	86	33	70
10	65	73	66	68	25	95	100	20	74
11	80	93	93	68	26	80	80	6	58
12	85	93	93	90					
13	85	100	93	92					
14	70	73	66	70					
15	90	100	93	94					

Task Number	MOS				Task Number	MOS			
	24E	24J	24H	Combined		24E	24J	24H	Combined
EE19					EE21				
1	100	100	20	76	1	100	93	73	90
2	90	80	20	66	2	100	86	73	88
3	80	93	26	68	3	40	20	53	38
4	100	100	26	78	4	95	86	73	86
5	95	93	20	72	5	85	33	53	60
6	100	100	26	78	6	75	60	66	68
7	100	100	26	78	7	45	53	53	50
EE20					EC22				
1	100	100	26	78	1	100	100	93	98
2	90	73	20	64	2	100	100	86	96
3	80	93	20	66	3	100	86	93	94
4	100	100	26	78	4	80	46	60	64
5	95	100	13	72	EC23				
6	100	100	20	76	1	100	100	100	100
7	100	100	26	78	2	100	100	100	100

Task Number	MOS 24E	24J	24H	Combined
EC23				
3	100	100	100	100
EC24				
1	100	100	100	100
2	95	100	100	98
3	95	100	93	96
4	85	100	100	94
EC25				
1	100	100	100	100
2	95	100	100	98
3	95	100	93	96
4	45	60	60	54
EC26				
1	95	100	100	98
2	95	100	100	98
3	95	100	100	98

Task Number	MOS 24E	24J	24H	Combined
EC27				
1	95	100	100	98
2	100	100	100	100
3	95	100	93	96
EC28				
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
EC29				
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
4	20	33	46	32
EC30				
1	100	100	100	100
2	100	100	100	100

Task Number	MOS 24E	MOS 24J	MOS 24H	Combined
EC30				
3	100	100	100	100
EC31				
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
EC32				
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
EC33				
1	100	100	100	100
2	100	100	93	98
3	95	100	100	98
4	80	86	93	86
EC34				
1	90	100	100	96

Task Number	MOS 24E	MOS 24J	MOS 24H	Combined
EC34				
2	90	100	100	96
3	90	100	93	94
4	40	80	46	54
5	20	53	26	32
EC35				
1	90	73	93	86
2	90	73	86	84
3	90	73	86	84
4	35	40	46	40
5	15	13	26	18
EC36				
1	100	93	100	98
2	100	93	100	98
3	100	93	100	98
4	90	93	86	90
5	70	86	66	74

Appendix F

Maintenance Supervisor Questionnaires

Appendix F

MAINTENANCE SUPERVISOR QUESTIONNAIRES

Qualification criteria questions:

1. When a new school graduate is assigned to your unit how long is it before he is given system maintenance responsibility on his own?

2. How do you determine when he is ready for such responsibility?

   a. What does he have to do to demonstrate to you that he can perform the required duties?

   b. Do you test him in any way? If so, how?

   c. What kinds of skills and knowledges must he have before you feel he can do the work?

3. When he first comes on site, are there any tasks that you absolutely will not allow him to perform? Which ones?

4. What pieces of equipment do you let him work on and which items do you tell him to keep away from?

5. Some mechanics and repairmen are considered to be more proficient in performing the maintenance function than others. Have you found this to be true?

6. Would you describe for me the best maintenance man you have had on the Hawk system?

7. Would you describe for me the least capable technician you have ever supervised?

8. Rate the following kinds of tasks in terms of their importance in rating maintenance personnel as fully qualified:

1. Much less important than the other kinds of tasks.

2. Somewhat less important than the other kinds of tasks.

3. No less or more important than the other kinds of tasks.

4. Somewhat more important than the other kinds of tasks.

5. Much more important than the other kinds of tasks.

- Periodic Check Tasks
- Preventive Maintenance Tasks
- Malfunction Diagnosis Tasks
- Corrective Maintenance Tasks

Appendix F

NAME RANK MOS

This form has been developed from information provided by supervisors (NCO's and Warrant Officer's) and managers (Unit Commanding Officer's) of electronic maintenance technicians. The kinds of evaluation of a technician's job performance. This study is trying to determine to what degree these kinds of evaluation dimensions do in fact influence proficiency ratings.

Please indicate the degree to which the ratee performs each activity. Your rating should be based upon all of your observations of the man's behavior, not just of his maintenance work.

0	1	2	3	4
Never	Less than half the time	About half of the half	More than half of the time	Always

_______ 1. Quickly and correctly identifies malfunction causes.

_______ 2. Demonstrates clear understanding of job objectives and work standards.

_______ 3. Performs mechanical tasks correctly, using the proper tools.

_______ 4. Replaces tools and test equipment after performing maintenance activities.

_______ 5. Uses good work habits.

_______ 6. Works efficiently, not wasting resources (time, tools, materials).

_______ 7. Meets time schedules when he has control of conditions.

_______ 8. Learns quickly, having to be shown how to do something only once or twice.

_______ 9. Appropriately applies theory to equipment functioning.

_______ 10. Performs all work that needs to be done.

_______ 11. Uses all hardware (washers, nuts, bolts, screws) when replacing or installing components.

_______ 12. Is alert on the job, demonstrating an awareness of possible non-safe working conditions.

_______ 13. Has someone with him when working on energized equipment.

_______ 14. Follows safe operating procedures.

_______ 15. Interacts with others with little or no conflict.

_______ 16. He asks questions when in doubt, does not make wild guesses.

_______ 17. Assumes all job responsibilities.

0	1	2	3	4
Never	Less than half the time	About half of the time	More than half of the time	Always

_______ 18. He eagerly looks for work, and is willing to work.

_______ 19. Demonstrates emotional maturity, not over-reacting in problem or crisis situations--taking things in stride.

_______ 20. He persists in his work staying with a task until it is completed.

_______ 21. Demonstrates pride in his job by demanding work be done correctly and by discussing past successful job performance.

_______ 22. He is reliable and can be counted on to carry out assigned and implied duties.

_______ 23. Plans the job--determines what procedures he must carry out and obtains the necessary tools, test equipment, schematics, TM's and other references prior to starting the job.

_______ 24. He demonstrates a higher level of education than the average soldier.

_______ 25. Correctly completes all reports, requisitions, and other paperwork.

_______ 26. Reads schematics correctly.

_______ 27. He is logical in his approach to troubleshooting, not offering irrational explanations of problems.

_______ 28. Uses all test equipment available called for in the procedures.

_______ 29. Performs malfunction diagnosis deliberately and in an orderly fashion and does not jump to conclusions.

_______ 30. Manages work activities of others efficiently.

_______ 31. Does not take shortcuts.

_______ 32. He is honest; he has done all work he reports having completed.

0	1	2	3	4
Never	Less than half the time	About half of the time	More than half of the time	Always

_______ 33. Keeps supervisors correctly and completely informed as to work status.

_______ 34. He is ambitious, doing his job well in order to become eligible for promotion.

_______ 35. Correctly and quickly locates parts/components on equipment.

_______ 36. Uses correct technical references and does not rely on memory.

_______ 37. Takes care of tools and test equipment.

_______ 38. Performs all required steps, not omitting necessary procedures.

_______ 39. Explains problems and causes so others can understand.

_______ 40. He helps others, often volunteering to assist others with maintenance problems.

_______ 41. Has a high level of work endurance, working long periods of time if necessary.

_______ 42. Does not engage in horseplay when performing maintenance activities.

_______ 43. Performs all preventive maintenance tasks.

_______ 44. He does not evade work activities.

_______ 45. He demonstrates a wide range of interests.

_______ 46. Recognizes unusual conditions as special problems.

_______ 47. Does not carelessly touch or lean on energized components or allow others to do so.

_______ 48. When he cannot perform a work procedure or does not possess work related information, he willingly learns what is needed for successful job performance.

0	1	2	3	4
Never	Less than half the time	About half of the time	More than half of the time	Always

_______ 49. Keeps work area clean and protects equipment from spills, dirt, and moisture while performing maintenance activities.

_______ 50. Initiates work activities, not waiting to be told what has to be done.

_______ 51. Pays attention to instruction, having to be told only once to do something.

Appendix F

Evaluation Form for Electronic Maintenance Technicians

This form has been developed from information provided by supervisors (NCO's and Warrant Officer's) and managers (Unit Commanding Officer's) of electronic maintenance technicians. The kinds of evaluation information represented by these twenty items may influence a rater's evaluation of a technician's job performance. This study is trying to determine to what degree these kinds of evaluation dimensions do in fact influence proficiency ratings.

Please indicate the degree to which the ratee performs each activity. Your rating should be based upon all of your observations of the man's behavior, not just of his maintenance work.

NAME RANK MOS

0	1	2	3	4
Never	Less than half the time	About half of the time	More than half of the time	Always

_______ 1. Quickly and correctly identifies malfunction causes.

_______ 2. Performs all work that needs to be done.

_______ 3. Uses all hardware (washers, nuts, bolts, screws etc.) when replacing or installing components.

_______ 4. Is alert on the job, demonstrating an awareness of possible non-safe working conditions.

_______ 5. Follows safe operating procedures.

_______ 6. He asks questions when in doubt, does not make wild guesses.

_______ 7. He persists in his work, staying with a task until it is completed.

_______ 8. He is reliable and can be counted on to carry out assigned and implied duties.

_______ 9. Plans the task--determines what procedures he must carry out and obtains the necessary tools, test equipment, schematics, TM's and other references prior to starting the task.

_______ 10. Reads schematics correctly.

_______ 11. Uses all test equipment available called for in the procedures.

_______ 12. Performs malfunction diagnosis deliberately and in an orderly fashion and does not jump to conclusions.

_______ 13. He is honest he has done all work he reports having completed.

_______ 14. Keeps supervisors correctly and completely informed as to work status.

_______ 15. Uses correct technical references and does not rely on memory.

0	1	2	3	4
Never	Less than half the time	About half of the time	More than half of the time	Always

_______ 16. Takes care of tools and test equipment.

_______ 17. Performs required steps, not omitting necessary procedures.

_______ 18. Performs all preventive maintenance tasks.

_______ 19. Initiates work activities, not waiting to be told what has to be done.

_______ 20. Pays attention to instruction, having to be told only once to do something.

Appendix G

Basic Electronic's Skill and Knowledge Tests

Test Administration Instructions

These instructions describe the procedures to be followed for the administration and scoring of a test for measuring electronic maintenance skills and knowledges that are basic (fundamental) to the performance of the job in MOS 24E, 24H and 24J. The test is divided into two general sections: a section with performance-oriented items using paper/pencil type questions; and a section with performance items similar to those actually performed on the job. The second section requires that certain preparations be carried out prior to test administration. This is necessary to insure that tests conditions are standard for each examinee.

PREPARATION FOR THE TEST

To prepare for each administration of the test, you must accomplish the following:

1. When more than one examinee is to be tested at one time, plan the order in which sections of the test will be administered to each examinee.
2. Assemble all required equipment materials and tools, including question and answer forms and pencils.
3. Set up the performance test stations in the same manner for each examinee as follows on the next page.
4. For the test item requiring the identification of malfunctioning component, insert the faulty component before the examinee arrives at the testing site.
5. Check the location to insure safe operating conditions.

ADMINISTRATION OF THE TESTS

To administer the test, you must perform the following:

1. Explain the general purpose of the study.

This study is part of a research project that has the purpose of developing procedures for determining the subject matter for electronic training courses. The emphasis here is on basic electronic skills and knowledge. The test you are about to take was based upon analysis of the job performed in your MOS. The results of your performance on the test are to be used for research purposes only. Your specific results will not be shown to anyone. Neither your supervisor nor your battery commander will be shown the results. Do you have any questions about why you are here?

Answer any general questions, but delay answering questions about the specific nature of the test until after you have read the test instructions

2. Read the test instructions to the examinees as follows:

The test is divided into two sections. One is a paper/pencil test and the other a performance test. Specific instructions for each test item are written out in the test booklet. You will place your answer for each item in the space provided in the test booklet. For most of the items you only need make a check mark ( ) in the appropriate blank. The performance portion is timed. The written portion is not timed. As soon as you finish one section tell the test monitor and he will start you on the second section. All the equipment and materials needed for completing the performance test are provided. I will answer any administrative questions now or during the test.

Do you have any questions?

3. Start the test by saying, Go.

4. Observe the examinees doing the performance test. Answer any administrative questions, but do not answer questions about how to perform the required test activity.

5. Stop the examinee if he is about to initiate an action that will constitute a hazard to himself or to the equipment.

6. When an examinee finishes the first section of the test, get him started as soon as possible on the second part.

SCORING THE TEST

To determine the total score for each examinee, you must do the following:

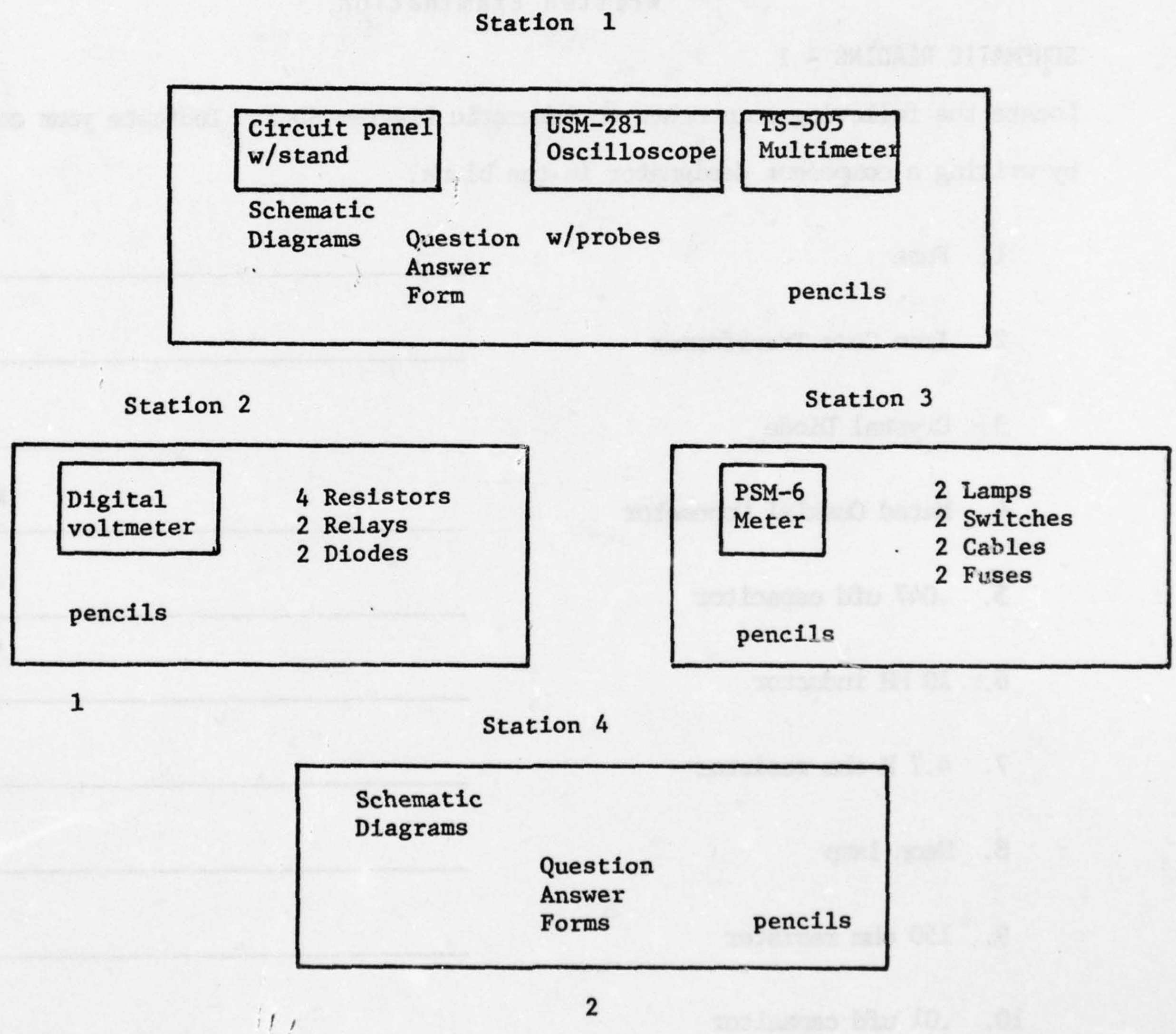
1. Score each item as correct or incorrect.

2. For each correct item weight them as follows:

1. Schematic Reading	(Items 1-20)	= 1.84 points
2. Electronic Terms	(Items 21-40)	= 1.36 points
3. Determining Resistor Value	(Items 41&42)	= 1.00 points
4. Conversion of Measurement Value	(Items 43-47)	= 1.12 points
5. Continuity Checks Use of PSM-6 Multimeter	(Items 48-55)	= 1.50 points
6. Component Checks Use of Digital Voltmeter	(Items 56-63)	= 1.58 points
7. Use of TS-505 Multimeter	(Item 64)	= 1.42 points
8. Use of USM-281 Oscilloscope	(Item 65)	= 1.68 points
9. Troubleshooting	(Item 66)	= 1.82 points

3. Add the total points to get the total score.

PERFORMANCE TEST STATION LAYOUT



month

Name ______ Rank ______ MOS ______ Electronic Work Experience ______

Last MOS Evaluation Score ______ Where Stationed ______

SECTION I

Written Examination

SCHEMATIC READING - 1

Locate the following components on Schematic Diagram SD-3. Indicate your answer by writing a component designator in the blank.

1. **Fuse** ______
2. **Iron Core Transformer** ______
3. **Crystal Diode** ______
4. **Mated Coaxial Connector** ______
5. **.047 ufd capacitor** ______
6. **10 MH inductor** ______
7. **4.7 K ohm resistor** ______
8. **Neon lamp** ______
9. **150 ohm resistor** ______
10. **.01 ufd capacitor** ______

SCHEMATIC READING - 2

Using Schematic Diagram - SD-4 identify the function of each of the following components. Indicate your answer by selecting a function from the list and placing its letter in the blank beside the component.

Function	Component
a. Adjusts output voltage	11. DS-1 ______
b. Filter capacitor	12. T-1 ______
c. Indicates power supply is on	13. R-2 ______
d. Diode limiter	14. S-1 ______
e. Surge suppressor	15. K-2 ______
f. Plate load resistor	16. R-9 ______
g. Filament transformer	17. C-4 ______
h. Provides overload protection	18. CR-1 ______
i. Enables power supply operation	19. V-1 ______
j. Dual Triode differential amplifier	20. R-15 ______
k. Part of a voltage divider	
l. Voltage regulator	

ELECTRONIC TERMS - 1

For each of the following terms indicate its definition by placing the appropriate letter in the blank.

Definitions	Terms
a. A device to open or close a circuit.	21. Relay ______
b. A remote control switching device.	22. Transformer ______
c. A voltage source.	23. Switch ______
d. A measure of conductance.	24. Battery ______
e. A component used to transfer electric energy from one circuit to another.	25. Short Circuit ______
f. A low resistance path for current.	26. Continuity ______
g. A component which has a controlled amount of resistance.	27. Capacitance ______
h. The property of a component to oppose current flow.	28. Resistor ______
i. A complete path for current flow.	29. Capacitor ______
j. A component which can store and release electric energy.	30. Resistance ______
k. A component which melts to open a circuit.	
l. The property of a component to store and release electric energy.	

ELECTRONIC TERMS - 2

For each of the following terms match the appropriate statement by placing a letter in the blank beside the term.

a. Ohm

b. Has a high resistance.

c. Omega

d. Potentiometer

e. Watt

f. Has a low resistance.

g. Has no resistance at all.

h. Ampere

i. A broken path in a circuit.

j. A double-acting switch.

k. A device that melts to open a circuit.

l. A device that opens a circuit when it is overheated.

m. A condition of a circuit breaker which restores current flow.

31. Good conductor ________

32. Unit of power ________

33. Good insulator ________

34. Unit of resistance ________

35. Unit of current ________

36. Variable resistor ________

37. Fuse ________

38. Thermal circuit breaker ________

39. Reset ________

40. Open ________

DETERMINING RESISTOR VALUE

Determine resistance value and tolerance of the following resistors by reading their color code.

41. Band 1 - brown
    Band 2 - blue
    Band 3 - red Value ________________
    Band 4 - silver Tolerance ________________

42. Band 1 - orange
    Band 2 - green
    Band 3 - yellow Value ________________
    Band 4 - gold Tolerance ________________

CONVERSION OF MEASUREMENT VALUE

Convert the following measurements from the first scale to the second scale.

43. 1,000 volts is equal to: ________________ kilovolts

44. 2.8 kilohms is equal to: ________________ ohms

45. 250 milliamperes is equal to: ________________ amperes

46. 750 milliseconds is equal to: ________________ seconds

47. 0.2 volt is equal to: ________________ millivolts

SECTION II

Performance Test

CONTINUITY CHECKS (Time limit 10 minutes)

Perform a continuity check on the following components using the PSM-6 multimeter. Indicate whether the component is GOOD or BAD by placing a check mark (✓) in the blank space to the right of your answer.

48. Lamp DS-1 GOOD ________ BAD ________

49. Lamp DS-2 GOOD ________ BAD ________

50. Switch S1 GOOD ________ BAD ________

51. Switch S2 GOOD ________ BAD ________

52. Cable C1 GOOD ________ BAD ________

53. Cable C2 GOOD ________ BAD ________

54. Fuse F1 GOOD ________ BAD ________

55. Fuse F2 GOOD ________ BAD ________

Time Limit 10 Minutes

COMPONENT CHECK

Check the following components to determine whether each is GOOD or BAD. Use the Digital Voltmeter to perform the test. Indicate your answer by placing a check mark (✓) in the appropriate blank.

56. Diode CR1 GOOD ______ BAD ______

57. Diode CR2 GOOD ______ BAD ______

58. Relay K1 GOOD ______ BAD ______

59. Relay K2 GOOD ______ BAD ______

RESISTANCE DETERMINATION

Measure the resistance of the following resistors using the Digital Voltmeter. Indicate your answer by writing a value in the blank beside each component designation.

60. Resistor R1 ______________________

61. Resistor R2 ______________________

62. Resistor R3 ______________________

63. Resistor R4 ______________________

CIRCUIT MALFUNCTION DIAGNOSIS

(Time limit 5 minutes)

64. Check circuit CKT #1 for proper functioning using the TS-505 Multimeter. Indicate whether you get the proper voltage at the output test point. The schematic diagram for CKT #1 is provided for your use.

Correct Voltage Yes ____________ No ____________

(Time limit 5 minutes)

65. Check circuit CKT #2 for proper functioning using the USM-281 Oscilloscope. The circuit schematic is provided for your use.

Correct Waveform Yes ____________ No ____________

(Time limit 15 minutes)

66. If your answer to Question 65 is NO, identify the source of malfunction. Indicate your answer by writing a component number in the blank. The circuit schematic diagram is provided for your use.

Malfunction ______________________________

DATA REQUIRED BY THE PRIVACY ACT OF 1974
(5 U.S.C. 552a)

TITLE OF FORM
Basic Electronic Performance Test and Evaluation

PRESCRIBING DIRECTIVE
AR 70-1

1. AUTHORITY

10 USC Sec 4503

2. PRINCIPAL PURPOSE(S)

The data collected with the attached form are to be used for research purposes only.

3. ROUTINE USES

This is an experimental personnel data collection form developed by the U. S. Army Research Institute for the Behavioral and Social Sciences pursuant to its research mission as prescribed in AR 70-1. When identifiers (name or Social Security Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

4. MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of the research, but there will be no effect on individuals for not providing all or any part of the information. This notice may be detached from the rest of the form and retained by the individual if so desired.

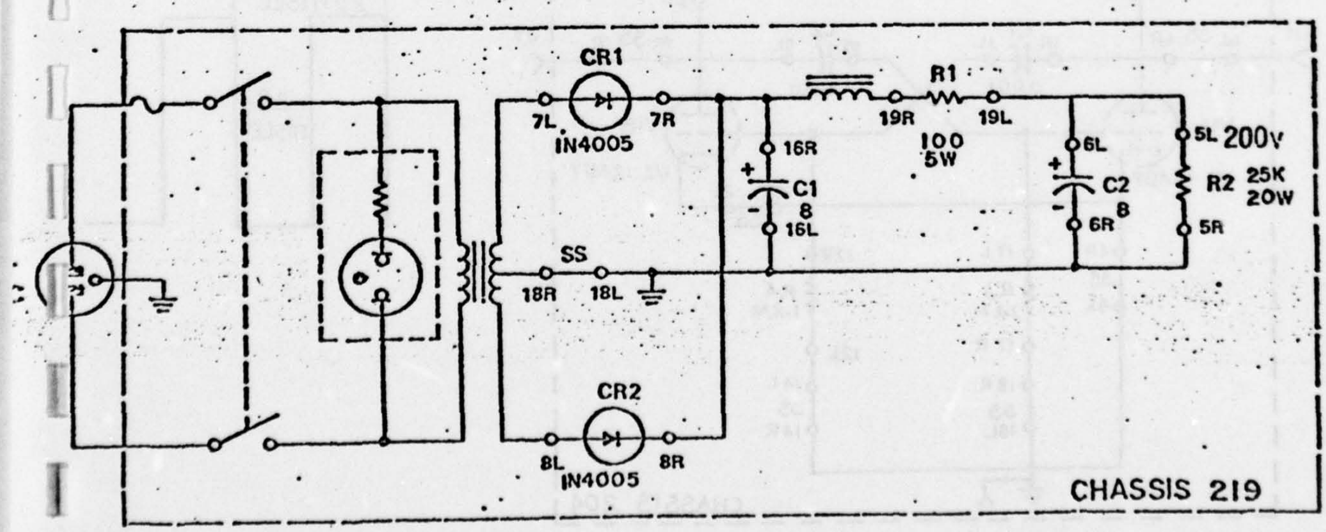
CKT# 1

The printed wiring surface of the circuit board faces outward from the rear of the chassis and is clearly visible. The jacks in the circuit board are arranged in two vertical columns providing 20 component positions. A complete position designation for any component position includes a number (1 to 20) plus the designation L or R which identifies each end of the component. All components are mounted on plastic strips with banana plugs on each end. Turn power off prior to removing or replacing component strips.

SS indicates - shorting strip

Component Layout

1R-1	11R-L
2	12
3	13
4	14
5	15
6	16
7	17
8	18
9	19
10	20



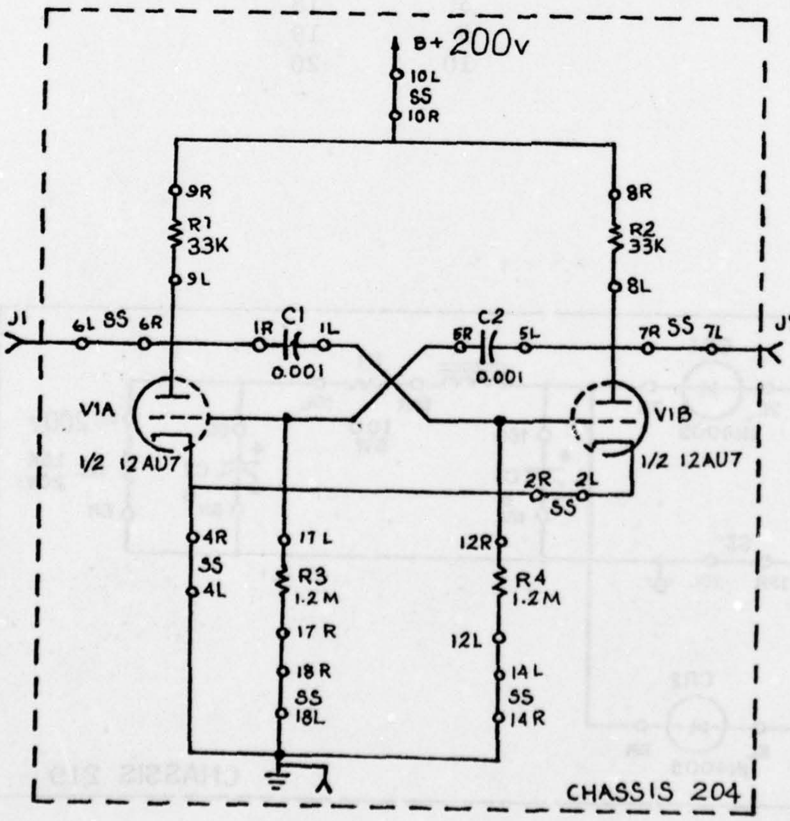
CKT# 2

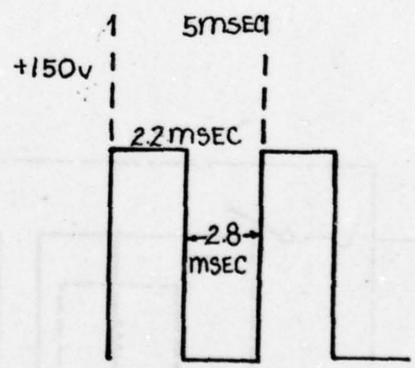
The printed wiring surface of the circuit board faces outward from the rear of the chassis and is clearly visible. The jacks in the circuit board are arranged in two vertical columns providing 20 component positions. A complete position designation for any component position includes a number (1 to 20) plus the designation L or R which identifies each end of the component. All components are mounted on plastic strips with banana plugs on each end. Turn power off prior to removing or replacing component strips.

SS indicates - shorting strip

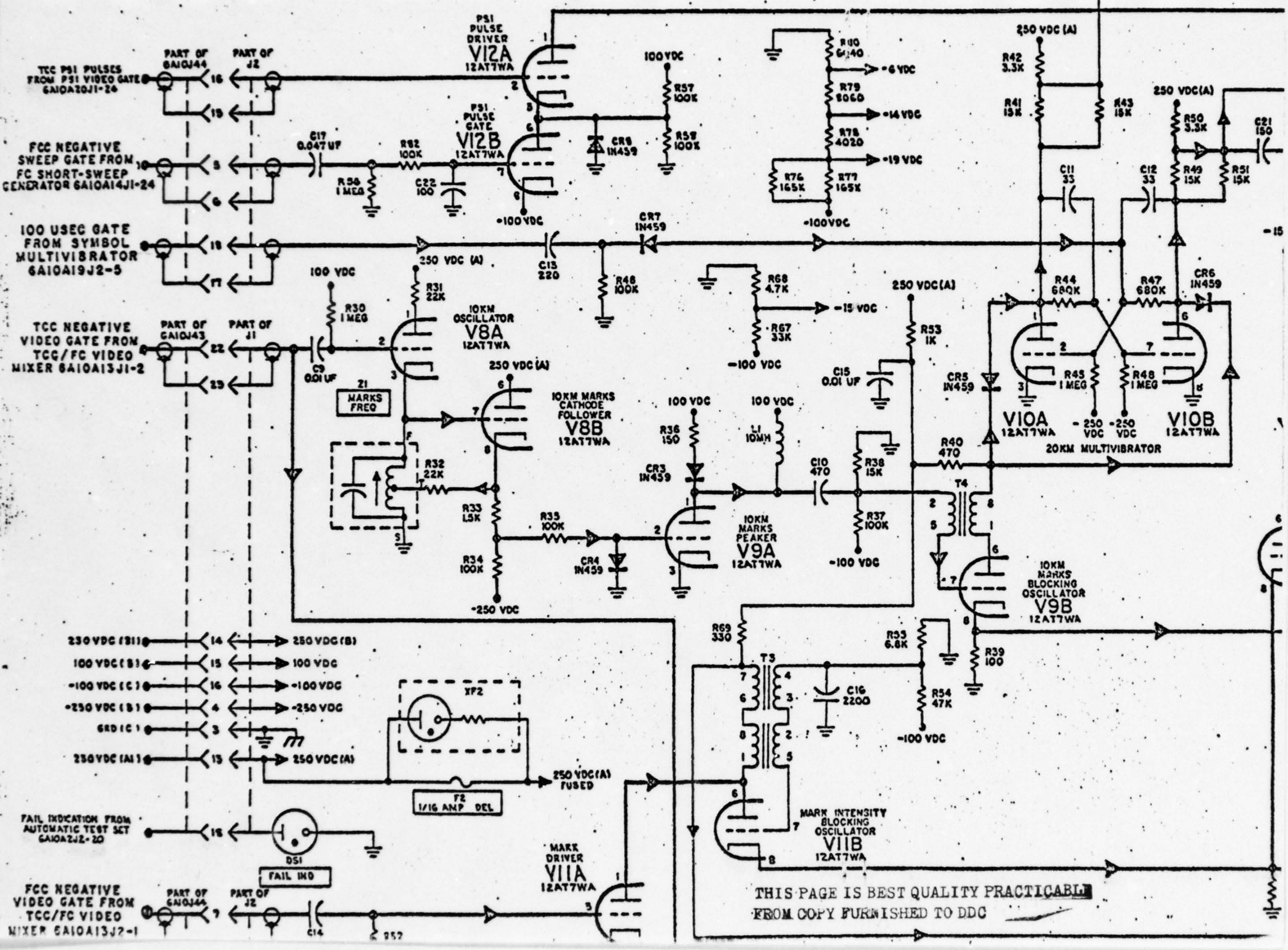
Component Layout

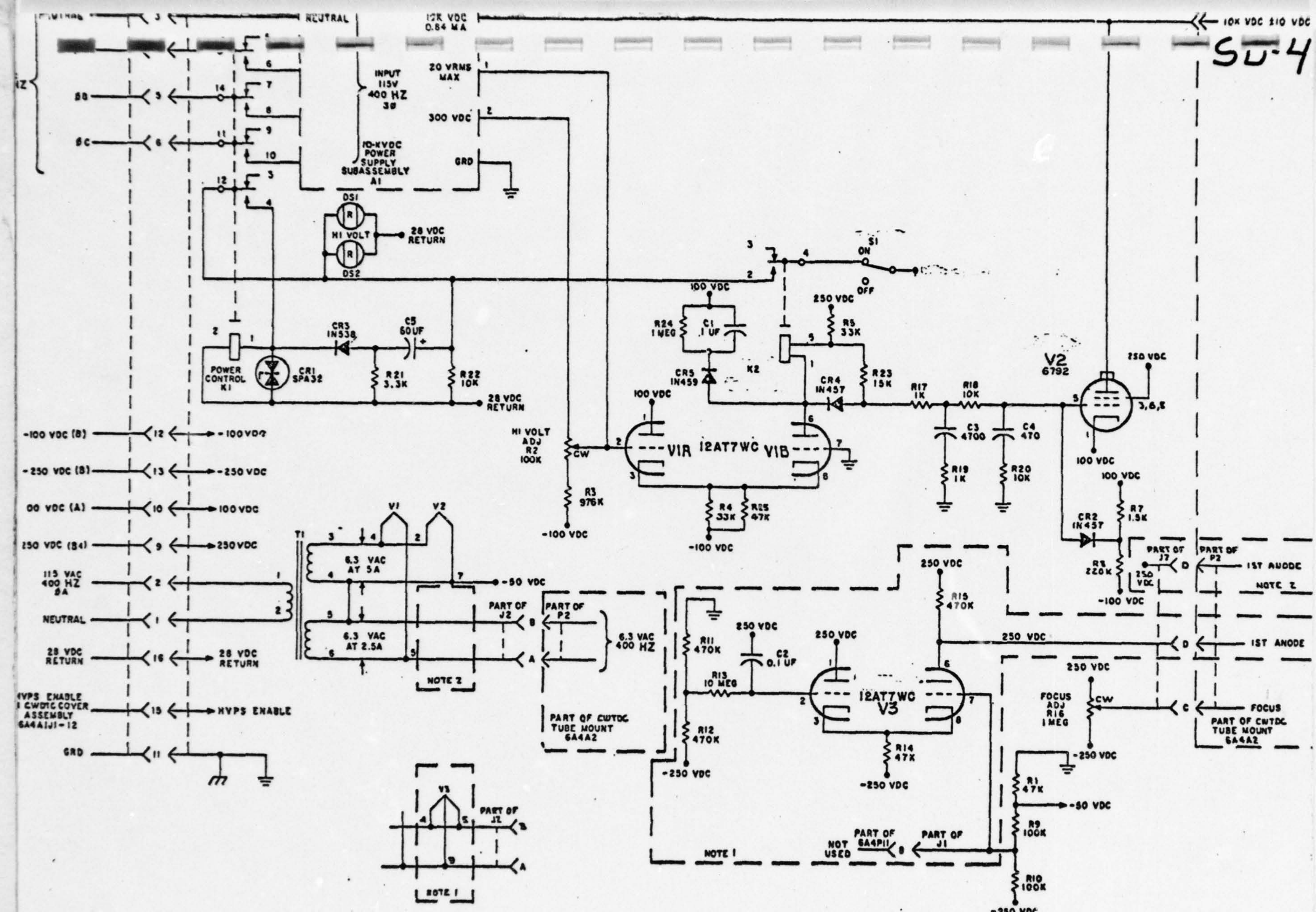
1R-L	11R-1
2	12
3	13
4	14
5	15
6	16
7	17
8	18
9	19
10	20





SD-3


TCC PS1 PULSES FROM PS1 VIDEO GATE 6A10A20J1-24
FCC NEGATIVE SWEEP GATE FROM FC SHORT-SWEEP GENERATOR 6A10A14J1-24
100 USEC GATE FROM SYMBOL MULTIVIBRATOR 6A10A19J2-5
TCC NEGATIVE VIDEO GATE FROM TCG/FC VIDEO MIXER 6A10A13J1-2
FAIL INDICATION FROM AUTOMATIC TEST SET 6A10A2J2-20
FCC NEGATIVE VIDEO GATE FROM TCC/FC VIDEO MIXER 6A10A13J2-1
PART OF 6A10J44
PART OF J2
PART OF 6A10J43
PART OF J1
PS1 PULSE DRIVER V12A 12AT7WA
PS1 PULSE GATE V12B 12AT7WA
10KM OSCILLATOR V8A 12AT7WA
10KM MARKS CATHODE FOLLOWER V8B 12AT7WA
10KM MARKS PEAKER V9A 12AT7WA
10KM MARKS BLOCKING OSCILLATOR V9B 12AT7WA
V10A 12AT7WA
V10B 12AT7WA
20KM MULTIVIBRATOR
MARK INTENSITY BLOCKING OSCILLATOR V11B 12AT7WA
MARK DRIVER V11A 12AT7WA
Z1 MARKS FREQ
XF2
F2 1/16 AMP DEL
DS1
FAIL IND
250 VDC(A) FUSED
250 VDC(B)
100 VDC
-100 VDC
-250 VDC
GRD(C)
250 VDC(A)
-6 VDC
-14 VDC
-19 VDC
-15 VDC
C17 0.047 UF
R62 100K
R56 1 MEG
C22 100
R57 100K
R58 100K
CR8 1N459
CR7 1N459
C13 220
R46 100K
R31 22K
R30 1 MEG
C9 0.01 UF
R32 22K
R33 1.5K
R34 100K
R35 100K
CR4 1N459
R36 150
CR3 1N459
L1 10MH
C10 470
R38 15K
R37 100K
R68 4.7K
R67 33K
R53 1K
C15 0.01 UF
R40 470
T4
CR5 1N459
R42 3.3K
R41 15K
R43 15K
C11 33
R44 680K
R45 1 MEG
R47 680K
R48 1 MEG
C12 33
R50 3.3K
R49 15K
R51 15K
C21 150
CR6 1N459
R80 6140
R79 8060
R78 4020
R76 165K
R77 165K
R69 330
T3
C16 2200
R55 6.8K
R54 47K
R39 100
C14
R52


SD-4
NEUTRAL
12K VDC 0.84 MA
10K VDC ±10 VDC
INPUT 115V 400 HZ 3Ø
10-KVDC POWER SUPPLY SUBASSEMBLY A1
20 VRMS MAX
300 VDC
GRD
ØB
ØC
DS1
HI VOLT
DS2
28 VDC RETURN
S1
ON
OFF
POWER CONTROL K1
CR1 SPA32
CR3 1N538
C5 60UF
R21 3.3K
R22 10K
R24 1 MEG
C1 .1 UF
CR5 1N459
K2
R5 33K
R23 15K
CR4 1N457
R17 1K
R18 10K
C3 4700
C4 470
R19 1K
R20 10K
V2 6792
100 VDC
250 VDC
-100 VDC
HI VOLT ADJ R2 100K
R3 976K
V1A 12AT7WC V1B
R4 33K
R25 47K
CR2 1N457
R7 1.5K
R8 220K
-100 VDC (B)
-250 VDC (B)
100 VDC (A)
250 VDC (B4)
115 VAC 400 HZ ØA
NEUTRAL
28 VDC RETURN
HVPS ENABLE
GRD
T1
6.3 VAC AT 5A
6.3 VAC AT 2.5A
-50 VDC
PART OF J2
PART OF P2
6.3 VAC 400 HZ
NOTE 2
PART OF CWTDC TUBE MOUNT 6A4A2
PART OF J7
1ST ANODE
R11 470K
R12 470K
R13 10 MEG
C2 0.1 UF
12AT7WC V3
R14 47K
R15 470K
FOCUS ADJ R16 1 MEG
FOCUS
R1 47K
R9 100K
R10 100K
-250 VDC
PART OF J1
PART OF 6A4P11
NOT USED
NOTE 1

Appendix H

Average Test Performance
for Individual Technicians

Appendix H
Average Test Performance for Individual Technicians (24E)

Rank	Exp.	MOS Score	1	2	3	4	5	6	7	8	9	Rating	Weighted Test Score
E-3	5		80	95	0	60	88	13	0	10	0	74	664
	10		80	95	0	40	10	50	0	10	0	37	718
	4		90	30	0	0	10	25	10	10	0	59	706
	5		80	90	10	40	10	88	0	0	0	73	711
	5		65	30	0	0	63	63	0	0	0	74	354
	5		85	85	0	0	75	75	10	0	10	24	827
	5		95	30	0	80	10	50	10	0	0	69	676
	5		80	45	0	20	63	50	0	10	0	72	572
	8		95	85	50	40	10	25	10	10	0	23	885
	11		90	95	0	10	10	50	0	0	10	48	818
	5		95	80	0	40	10	50	10	10	0	74	867
	4		10	90	0	60	75	50	10	10	0	74	875
E-4	10		70	60	0	40	10	38	0	10	0	70	633
	15		90	85	0	40	10	88	0	10	0	41	783
	15		90	70	0	80	75	10	0	10	0	75	789
	14		80	65	0	20	10	75	10	10	0	76	837

Appendix H
Average Test Performance for Individual Technicians (24E)

Rank	Exp.	MOS Score	1	2	3	4	5	6	7	8	9	Rating	Weighted Test Score
E-5	36	99	75	40	0	0	10	63	10	0	0	72	584
	30	100	90	50	0	0	10	38	10	0	10	78	768
	33	115	85	50	0	20	88	63	0	10	0	74	646
	16	139	95	95	0	80	10	50	0	10	10	71	973
	48	119	80	65	0	40	10	25	10	0	0	60	612
	47	96	80	80	0	0	10	13	0	0	10	69	617
E-6-7	145	103	80	85	50	60	10	10	0	0	10	80	870
	60	110	80	65	0	10	10	40	10	10	0	80	871
	126	98	10	10	50	40	10	80	10	10	0	36	1001
	27	98	90	65	50	40	75	75	10	10	0	77	890
	120	100	95	90	0	60	88	75	10	10	0	67	925
	69	110	80	90	0	60	10	88	0	0	0	75	626

Appendix H

Average Test Performance for Individual Technicians (24H)

Rank	Exp.	MOS Score	1	2	3	4	5	6	7	8	9	Rating	Weighted Test Score
E-3	8		95	70	50	80	100	75	100	100	0	80	988
	2		70	75	0	60	100	38	100	100	100	35	1000
E-4	12	115	95	85	0	100	100	38	100	100	100	71	1104
	21		95	85	0	40	100	88	0	0	0	63	624
	2		90	90	0	100	100	63	100	100	0	74	959
	4		95	90	100	60	100	88	0	100	0	50	921
	17		90	95	100	100	100	10	100	100	0	57	1125
E-5	21	125	95	80	0	10	100	75	10	100	0	80	974
	2		90	100	100	10	100	75	0	100	100	75	1132
	20		85	85	0	40	88	100	0	100	100	39	957
	37	125	90	70	100	10	100	63	10	100	0	42	890
	61	118	85	80	0	60	100	75	0	100	0	34	781
E-6	100	115	75	95	0	60	88	50	10	10	0	75	855
	21	138	75	85	50	10	75	75	10	10	0	69	932
	47	133	95	80	0	10	88	75	0	0	10	76	828
	48	100	95	75	10	10	10	88	10	0	10	65	1102

Appendix H
Average Test Performance for Individual Technicians (24J)

Rank	Exp.	MOS Score	1	2	3	4	5	6	7	8	9	Rating	Weighted Test Score
E-4	18		95	90	10	40	10	75	10	10	0	40	1021
	18		90	60	0	60	88	88	10	0	0	45	727
	20		85	95	10	10	10	75	10	10	0	41	1076
	15		95	85	0	80	10	10	0	0	0	70	688
	20		90	80	50	40	10	38	0	0	0	77	579
E-5	45	134	90	10	10	10	10	88	10	0	0	80	1045
	10		10	85	10	80	10	56	0	0	10	78	910
	22		95	90	10	10	10	10	10	10	0	80	1127
	48	90	95	85	10	20	10	50	10	0	0	54	784
	72	88	95	80	10	40	10	88	10	10	10	31	1209
	36	140	95	45	10	0	10	56	10	10	0	34	884
	46	115	10	95	50	10	10	88	10	10	10	45	1256
E-6	100	123	95	95	10	10	88	75	10	10	10	80	1259
	72	98	95	95	10	80	10	75	0	0	0	69	762
	60	98	90	80	0	20	88	75	10	0	10	62	871

Appendix I

Guidelines For Using

The Task Inventory Matrix (TIM)

and

The Task Analytical Process Model (TAPM)

Guidelines for Using the Task Inventory Matrix (TIM) and the Task Analytical Process Model (TAPM)

Your work during this project will be to perform a detailed task analysis of selected tasks in your MOS. A process will be used that was developed during an Army Research Institute sponsored research project. The emphasis is to identify Basic Skills and Knowledge used by maintenance personnel on-the-job, using the Task Analytical Process Model (TAPM).

The work to be performed during this project is:

1. Construct a Task Inventory Matrix by:
   a. Using the appropriate Technical Manuals and other pertinent publications.
   b. Using your own subject matter expertise.
2. Administer the TIM to job incumbents in the MOS.
3. Analyze the TIM results.
4. Select specific Tasks to be analyzed in detail.
5. Validate the procedures for performing the selected tasks by:
   a. Reviewing Technical Documentation
   b. Personally performing the task
   c. Observing a maintenance man performing the task.
6. Analyze the Task elements by using the TAPM procedures.
   a. Interview
   b. Observation
   c. Review of a written step by step validated procedure.
7. Compile the results of the Task Analysis.
8. Review the list of skills and knowledge.

Background

The U.S. Army had been concerned about the problem of how much training and what kind of training the average soldier needs to be able to perform successfully as an electronic technician.

Generally, the answer has been determined to be that he needs at least two kinds of training. First, he must have a working knowledge of electronics, and second he must have a working knowledge of the maintenance tasks required for the system for which he is responsible. These two categories of training have been called BE (Basic Electronics) and systems training respectively.

The question of how much training is needed has tended to look at the depth of understanding that is necessary to perform the job successfully. A problem has existed almost as long as has this question in that the official definition of "perform successfully" has been disputed by field management personnel. The unit commander is driven by pressures to keep his unit equipment operational as much of the time as possible, regardless of the situations. Over the years, his definition has been that a good technician is one who can keep the system operational. It matters not that the technician must perform unauthorized tasks to accomplish this, or that he must fabricate a temporary fix in substitute for a non-available component.

The technician who can perform beyond the normal and authorized level of effort in earlier times was not rare. Early in the history of Air Defense systems, reference publications were more often than not incomplete, inaccurate, or not accessible. It became necessary to acquire not only functional knowledge and skills, but also theoretical knowledge and skills. The successful technician not only knew how a piece of equipment worked, he also found out why. He often had the performance capabilities of a design engineer.

These conditions have created a historically derived perceptual set that technicians can always use a more theoretical understanding of why an electronic system operates. This set has led to considerable research over the past two decades. Much of the work has been focused on how best to teach BE. The Functional Context approach to training was designed as a way of increasing the meaningfulness of BE. The Hawkeye approach inte-

grated basic troubleshooting concpets into a job aid. The multi-level training design was another attempt to integrate theory, training, and experience in the development of technical expertise. However, front-end-loading of electronic training with BE has tended to prevail in some form. The traditional instructor taught class and laboratory approach has been the most often used. The development of a common BE preparation course, COBET, given prior to a more specific BE concept course was attempted, but was not successful.

Numerous studies have been done over the past three decades by all of the military services in an effort to reduce complexity and cost of electronic maintenance training while producing more competent technicians. These studies have demonstrated repeatedly that enormous savings in training time and money are possible.

Part of the savings which these and other studies have demonstrated resulted from changes in the instructional approach and mode of presentation or from the use of simulators to provide more valid task practice. Novel types of performance aids have also been developed which simplified the tasks and made them both easier to perform and easier to learn. Yet, a common thread runs through them all, in fact, they are based on a careful examination of what the job incumbent does on the job and a restriction of course content to only material functionally related to job content. In almost every case, it has been possible through a systematic task identification and analysis to define a list of skills and knowledge necessary and sufficient for job task performance which limited training content to that list.

The purpose of this project is to determine the fundamental skills and knowledge required in the performance of your maintenance tasks. Accordingly, the following objectives are established for achieving this purpose:

1. Identify the task content of your job.

2. Identify requisite skills and knowledge for the electronic maintenance tasks.

3. Validate the electronic maintenance skills and knowledge.

Task Analytical Process Model Procedures

There are three steps in the process of analyzing task elements to the skills and knowledge level:

A. Construct a Task Inventory Matrix

B. Conduct the Task Element Analysis

C. Validate the Skills and Knowledge

The TAPM process is a logical analysis based upon experts job knowledge. All tasks however need not be analyzed in detail. Certain tasks should be selected for the detailed analysis and the remainder of tasks reviewed for unique skills and knowledges. To insure that the SME has not based his analysis on unique knowledge, a job description survey is constructed and administered to other technicians holding the same MOS. Details of the procedures are presented on the following pages. Follow the step by step process using the referenced examples.

A. Task Inventory Matrix

1. Construction of a Task Inventory Matrix

a. Assemble the appropriate Technical Manuals

TM-9-1430 12-1

TM-9-1430 24P

b. Select major item of equipment to be analyzed.

c. Using the maintenance allocation chart in the operator manual and the maintenance code in the parts manual, list the equipment items down to the lowest level of authorized repair. The listing of equipment should be made in a hardware grouping. For certain items it may be more appropriate to utilize a functional grouping. Criticality information can also be coded on TIM (see step 4b).

d. Test equipment that is used to perform maintenance and/or maintenance services on the end item should also be included in the TIM.

e. Determine the kinds of tasks that maintenance mechanics and repairmen perform on the equipment. This information may be obtained from the publications and your experience. Previous experience has determined there are four general categories of maintenance activities. A list of suggested task verbs and algorithms is at Table 1. An example of the TIM is at (pages 16 & 17).

f. A respondent data sheet or background information sheet should also be constructed and administered to provide information that is appropriate to the interpretation of the TIM results (example at page 15).

2. Administer the TIM

a. It is important to administer the TIM only to individuals who have had job experience in a real world environment. (Hands/on On site or in a DSU). The experience of an individual will determine their responses and we want to know what they "do" on the job.

b. Instructions to the TIM respondees must be written and included. You must explain to the responder how to complete the TIM. Administration should be completed on an individual using a one to one interview method. The written instructions are necessary to insure uniformity of interview procedures. Instructions may include a coding program to aid in TIM analysis, i.e.. If you have performed the task on the hardware item less than 10 times write the proper number. If you have performed the task more than 10 times write an X in the square.

3. Analyze the TIM results.

a. Compile the results of the TIM responses for all respondents by hardware item.

Table 1

Maintenance Task Verbs

Inspect:	To determine the serviceability of an item by examining its physical, mechanical and/or electrical characteristics and comparing the state of these characteristics with established standards. (Also to examine and to perform preventive maintenance.)
Test:	To verify serviceability of an item by measuring its mechanical and/or electrical characteristics and comparing these measurements with established standards. (Also to detect functional failure, to evaluate and to check).
Diagnose:	To isolate a malfunctioning item (component, module, subassembly or assembly) that is the source of operational failure. (Also to troubleshoot.)
Service:	To perform operations, such as cleaning, charging, and adding fuel, lubricants, cooling agents and air, on a periodic schedule to keep a system in proper operating condition. (Also to perform preventive maintenance.)
Adjust:	To bring an operating characteristic of an item into prescribed limits by setting variable controls to the specific, proper or exact positions.
Align:	To adjust specified variable elements of an item to bring about optimum or desired functional performance.
Calibrate:	To detect and adjust any discrepancy in the accuracy of on instrument (measurement or diagnostic equipment) when compared to an instrument which is a certified standard of known accuracy.
Install:	To seat or fix into position an item (component, module, subassembly or assembly) in a manner to allow the proper functioning of equipment or a system. (Also to emplace.)
Replace:	To remove a non-functioning item and to substitute a serviceable like-type part, subassembly, module (component or assembly) in a manner to allow the proper functioning of an equipment/system. (Also to assemble and disassemble.)
Repair:	To restore an item to serviceable condition. Consists of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to correct specific damage,

fault, malfunction, or failure in a part, subassembly, module/component/assembly, end item or system.

Overhaul: To restore an item to a completely serviceable/operational condition as prescribed by maintenance standards. This is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

Rebuild: To restore unserviceable equipment to a like-new condition in appearance, performance, and life expectancy. This is accomplished through complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements (items) according to original manufacturing tolerances and specifications, and subsequent reassembly of the item. Rebuild is the highest degree of material maintenance applied to Army equipment.

Table 1 (cont.)

VERB	ALGORITHM
Abide by	Attitudes
Accepting	Attitudes
Accommodate	Problem Solving
Aquire	Steering & Guiding Continuous Movement
Activate	Motor Chaining
Adapt	Problem Solving
Adjust	Motor Chaining
Adjust to	Problem Solving
Advise	Communicating
Aim	Steering & Guiding Continuous Movement
Align	Motor Chaining
Allocate	Classifying
Analyze	Rule Using
Answer	Communicating
Anticipate	Rule Using
Apply	Rule Using
Arrange	Classifying
Assemble (Dis)	Motor Chaining
Assign	Classifying
Associate	Identifying Symbols
Attend	Monitoring
Calculate	Rule Using
Catalogue	Classifying
Categorize	Classifying
Characterize	Classifying
Check	Rule Using
Choose	Decision Making
Cite	Verbal Chaining
Classify	Classifying
Clean	Motor Chaining
Close/Open	Motor Chaining

Table 1 (cont.)

VERB	ALGORITHM
Collect	Classifying
Compare	Identifying Symbols
Compensate	Steering & Guiding Continuous Movement
Compile	Classifying
Comply with	Attitudes
Compose	Problem Solving
Compute	Rule Using
Conclude	Rule Using
Conform to	Attitudes
Connect (Dis)	Motor Chaining
Construct	Problem Solving
Contrast	Identifying Symbols
Contrive	Problem Solving
Control	Steering & Guiding Continuous Movement
Converse	Communicating
Convert	Rule Using
Coordinate	Rule Using
Copy	Motor Chaining
Correlate	Decision Making
Create	Problem Solving
Cut	Cross Motor Skills
Deduce	Rule Using
Demonstrate	Rule Using
Design	Problem Solving
Detect	Monitoring
Determine	Decision Making
Develop	Problem Solving
Devise	Problem Solving
Diagnose	Decision Making
Diagram	Rule Using
Differentiate	Identifying Symbols
Direct	Communicating

Table 1 (cont.)

VERB	ALGORITHM
Discern	Identifying Symbols
Discover	Problem Solving
Distinguish	Identifying Symbols
Divide	Classifying
Draft	Gross Motor Skills
Draw	Gross Motor Skills
Drive	Steering & Guiding Continuous Movement
Energize (De)	Motor Chaining
Enumerate	Verbal Chaining
Equate	Rule Using
Estimate	Rule Using
Evaluate	Rule Using
Examine	Rule Using
Explain	Rule Using
Express	Communicating
Extrapolate	Rule Using
Figure	Rule Using
File	Classifying
Fly	Steering & Guiding Continuous Movement
Generalize	Rule Using
Grade	Classifying
Grasp	Gross Motor Skills
Group	Classifying
Guide	Steering & Guiding Continuous Movement
Identify	Identify Symbols
Illustrate	Rule Using
Index	Classifying
Indicate	Identifying Symbols
Infer	Rule Using
Inform	Communicating
Inspect	Motor Chaining
Install	Motor Chaining

Table 1 (cont.)

VERB	ALGORITHM
Instruct	Communicating
Interpolate	Rule Using
Interpret	Rule Using
Interview	Communicating
Invent	Problem Solving
Inventory	Classifying
Isolate	Decision Making
Itemize	Verbal Chaining
Judge	Classifying
Label	Identifying Symbols
Lead	Steering & Guiding Continuous Movement
Lift	Gross Motor Skills
List	Verbal Chaining
Listen	Communicating
Listen for	Monitoring
Load	Motor Chaining
Locate	Identifying Symbols
Look for	Monitoring
Loosen	Gross Motor Skills
Lubricate	Motor Chaining
Maintain	Motor Chaining
Maneuver	Steering & Guiding Continuous Movement
Manipulate	Steering & Guiding Continuous Movement
March	Gross Motor Skills
Mate	Identifying Symbols
Match	Identifying Symbols
Mix	Gross Motor Skills
Monitor	Monitoring
Name	Identifying Symbols
Navigate	Steering & Guiding Continuous Movement
Observe	Monitoring
Operate	Motor Chaining

Table 1 (cont.)

VERB	ALGORITHM
Order	Communicating
Organize	Rule Using
Pick	Identifying Symbols
Pick up	Gross Motor Skills
Pilot	Steering & Guiding Continuous Movement
Plan	Rule Using
Predict	Rule Using
Prepare	Rule Using
Prescribe	Rule Using
Press	Gross Motor Skills
Program	Rule Using
Project	Rule Using
Pull	Gross Motor Skills
Push	Gross Motor Skills
Quote	Verbal Chaining
Rank	Classifying
Rate	Classifying
Reason	Problem Solving
Recall	Verbal Chaining
Recognize	Identifying Symbols
Regulate	Steering & Guiding Continuous Movement
Reiterate	Verbal Chaining
Relate	Verbal Chaining
Remove/Replace	Motor Chaining
Repeat	Verbal Chaining
Report	Communicating
Resist	Rule Using
Resolve	Problem Solving
Respond	Identifying Symbols
Restate	Verbal Chaining
Rotate	Gross Motor Skills
Run	Gross Motor Skills

Table 1 (cont.)

VERB	ALGORITHM
Schedule	Rule Using
Select	Decision Making
Service	Motor Chaining
Set	Motor Chaining
Set Up	Motor Chaining
Sew	Gross Motor Skills
Sharpen	Gross Motor Skills
Signal	Gross Motor Skills
Sing	Communicating
Slide	Gross Motor Skills
Solve	Rule Using
Sort	Classifying
Speak	Communicating
Specify	Identifying Symbols
Splice	Gross Motor Skills
Steer	Steering & Guiding Continuous Movement
Stencil	Gross Motor Skills
Study	Problem Solving
Stow	Motor Chaining
Swim	Gross Motor Skills
Synthesize	Problem Solving
Testify	Communicating
Think Through	Problem Solving
Tighten	Gross Motor Skills
Trace	Gross Motor Skills
Track	Steering & Guiding Continuous Movement
Transcribe	Rule Using
Translate	Rule Using
Trouble Shoot	Decision Making
Tune	Motor Chaining
Turn on/off	Motor Chaining
Twist	Gross Motor Skills

Table 1 (cont.)

VERB	ALGORITHM
Verify	Rule Using
Wait	Monitoring
Watch	Monitoring
Weld	Motor Chaining
Write	Motor Chaining

DATE__________________

NAME (LAST, FIRST, MIDDLE INITIAL) GRADE AGE

DUTY MOS ORGANIZATION

TIME IN PRESENT JOB TOTAL TIME IN SERVICE

TOTAL TIME IN ELECTRONICS FIELD

HIGHEST SCHOOL GRADE OR COLLEGE YEAR COMPLETED

HOW MUCH TIME DO YOU SPEND PERFORMING SUPERVISORY OR ADMINISTRATIVE FUNCTIONS?

______ NONE OF MY TIME. ______ 51-75% OF MY TIME.
______ 1-25% OF MY TIME. ______ 76-100% OF MY TIME.
______ 26-50% OF MY TIME.

HOW MUCH TIME DO YOU SPEND PERFORMING "HANDS ON" MAINTENANCE OF EQUIPMENT?

______ NONE OF MY TIME. ______ 51-75% OF MY TIME.
______ 1-25% OF MY TIME. ______ 75-100% OF MY TIME.
______ 26-50% OF MY TIME.

LIST THE TYPE OF TEST EQUIPMENT YOU USE ON THE JOB (PLEASE LIST FROM MOST FREQUENTLY USED DOWN TO LEAST FREQUENTLY USED).

WHERE DID YOU LEARN TO USE THE TEST EQUIPMENT (MOS SCHOOL, OTHER SCHOOL, OR OJT)?

WHAT MAINTENANCE ACTIVITIES DO YOU PERFORM THAT WERE NOT TAUGHT IN SCHOOL OR SHOULD HAVE BEEN GIVEN MORE EMPHASIS?

The Task Inventory Matrix

The first column indicates the Functional Group number of the System Hardware item as referenced in the appropriate Technical Manual.

The second column indicates the total like items contained within the major item. No entry in this column indicates quantity of one.

The third column contains the short name of the Hardware item.

The fourth through seventh columns contain types of maintenance activities.

The last column is divided into two parts indicating the effect the Hardware item will have on the End item and the missile system if defective.

The column is divided into two parts for each item. The upper portion indicates the condition of the end item with the lower portion indicating the condition of the system when the particular hardware item is not functioning correctly or is missing.

R = Red indicating the end item or system is not operational if this hardware item is not functioning.

A = Amber indicating the end item or system is capable of limited operation if this hardware item is not functioning.

G = Green indicating the end item or system operation is not significantly degraded if this item is not functioning.

Functional Group Number		Total in Major Item	System Hardware Item	Preventive Maintenance	Periodic Checks	Corrective Maintenance	Diagnosis Troubleshooting
0100			Battery Control Central				
1200			Power Distribution Control				
1300			Synchro Buss Assembly				
1400			Tactical Control Console				
	1410		Relay Chassis				
	1430	8	Deflection Amplifier X and Y				
	1470	3	14 KV Power Supply				
	1500	4	Fan and Dimmer Assembly				
	1540		Relay Assembly				
	1600	3	Video Amplifier				
	1680		Defogging Relay Assembly				
	1700		Indicator Control				
	1750		Coordinate Data Control				

b. Compare the relevant background information of the respondents, (relevant information, may be years of experience, location of site duty, DS/GS assignments, age, rank) to their TIM responses.

c. Use the above information to determine reasons for variance between respondents.

4. Select specific tasks to be analyzed in detail.

a. The TIM provides the density data in terms of most often performed tasks by a majority of the technicians.

b. Criticality data can be obtained from two sources.

(1) Operational readiness criteria from AR220-1 Missile System Availability Indicator.

(2) TM-9-1425-525 ESC (to be applied to each equipment item rather than to each task). The rationale is that if a preventive maintenance task and periodic checks are not performed a debilitating problem might occur or go undetected that could lead to red-lining the system and if a problem does occur to cause a system to go down, troubleshooting and corrective maintenance must be performed to get the system back on the air. Therefore, if a technician cannot perform any maintenance task when it must be performed, the operational readiness criteria for classifying equipment status comes into play.

(3) The U.S. Army Missile Material Readiness Command collects malfunction and time to repair data for Improved HAWK battalions in Europe over the last few years. (This report is most helpful in narrowing the list of critical tasks). Example of such a list on page 19.

c. Review the higher density tasks from the TIM results. An example is at page 20.

d. Designate those tasks that require the same kinds of maintenance procedures as several other tasks.

e. Using the information from 4a, b, c, and d. Compile a final list of tasks selected for analysis. (An example of such a list is at page 21).

f. The number tasks actually selected for performance of the detailed element analysis will be determined by time and availability of equipment, material and personnel to this project.

Extract From Data Bank US Army Missile Materiel Readiness Command

(182 days) April 1-Sept. 30, 1977 (213 days) Mar 1-Sept. 30, 1977

Major Item IPAR		Org. Fail-232			DSU Failed 338		
Functional Group Number	Nomenclature	NO Failed	% of Failed	MMTR	NO Failed	% of Failed	MMTR
4600	Pressurization Unit	31	13.3	.86	43	12.7	3.69
1250	Cooler Liquid	23	9.9	1.42	24	7.1	2.25
2425	Delay Amplifier	16	6.9	1.71	34	10.1	2.9
2415	Carrier Generator	15	6.4	1.33	32	9.5	3.6
3550	High Voltage Power Supply	14	6.0	2.66	23	6.8	2.2
2465	Video Integrator	9	3.8	1.51	13	3.9	.53
4920	Modulator Sub. Assy.	8	3.4	1.64	10	3.0	1.95
2455	MTI Amp.	7	30	170	12	3.6	4.08
		123	53%		191	56.5%	

MOS 24J

The IPAR chassis that eighty to one hundred percent of the MOS 24J respondents performed maintenance t asks on at least ten times are listed below.

Functional Group Number	Chassis Name	Functional Group Number	Chassis Name
1060	Dickie Fix Amplifier	2455	MTI Amplifier
1070	Dickie Fix-Fix Amplifier	2605	Voltage Regulator
1090	Interference Blanker	2620	Reference Voltage Regulator
1120	Back Bias Amplifier	4250	Trigger Pulse Amplifier
2245	Rangemark Generator		
2405	MTI Video Amp and MOB		
2415	Carrier Generator		
2425	Delay Amp (Long and Short)		
2435	Coho Oscillator		

Tasks Selected for Detailed Analysis

Task Number	Number Simular Task	MOS	
1	24	24E 24J	Electrically aline the stabilizing system, STALO, and preselector in the Improved Pulse Acquisition Radar. (IPAR)
2	4	24E 24J	Aline the STALO Automatic Frequency Control (AFC) in the IPAR.
3	24	24E 24J	Aline the Scan Servo Assembly in the Improved Battery Control Central (IBCC).
4	6	24E (24H)	Replace and check out the Cathode Ray Tubes (CRT) in the IBCC.
5	4	24E	Check Firing Console using Weekly check procedures in the IBCC.
6	12	24J 24H	Test the High Frequency Console using the self test procedures.
7	6	24H	Test the Display Generator at the High Frequency Console.
8	4	24H	Test the Range Speed Indicator at the High Frequency Console.
9	30	24H	Test the Scan Servo Assembly at the High Frequency Console.
10	35	24J	Test the AFC Amplifier at the High Frequency Console.
11	40	24J	Test the IF pre-amplifier at the High Frequency Console.
12	0	24J 24E	Replace the heat exchanger.
13	1	24J	Repair the heat exchanger.
14	2	24E	Replace the pressurization unit.
15	0	24J	Repair the pressurization unit.

5. Validate the procedures for performing the selected task.

a. A detailed step by step procedure must be written for each task and validated by:

(1) Your actual complete performance of the task.

(2) Your observation of a complete performance of the task.

b. Where the technical documentation of the task is a complete step by step procedure and has been validated (as in 5 a (1) or 5 a (2)) this procedure may be used in lieu of rewriting. The emphasis is that a 100% validation must be performed.

B. Task Element Analysis

1. Analyze the task elements by using the TAPM procedures.

a. The TAPM provides a systematic approach to performing a detailed task element analysis. The assumptions that must be made in using this process are:

(1) The task element descriptions are valid.

(2) The task element descriptions are complete.

(3) The user must have sufficient job knowledge to (ask) answer the process questions.

(4) The user does not have to be knowledgeable in the instructional development process.

(5) The user must be able to make decisions about general and special skills of the general public.

b. The detailed process begins with the initiation of the task and is carried through to task completion.

(1) The input element consists of initiating cues for the task and situation conditions. The cues indicated first that the task must now be carried out and second what standards must be met. The situation conditions will indicate what special considerations must be made in carrying out the task. (In your case the task has been selected as a result of the task selection process utilizing the analysis of the TIM).

(2) The processing element of the model includes the detailed activities that must be performed to complete the task. It includes the tools, equipment materials, facilities, support, and personnel that will be used to carry out the task.

(3) The output element consists of the finished product. This may be in the form of a repaired, checked, serviced or replaced equipment item. A comparison of the output against the input standards will lead to decision as to whether the task is complete.

2. Sequence of task element analysis.

Use the following flow chart to analyze the selected tasks in your MOS.

3. A suggested coding procedure for developing a list of skills and knowledge.

   a. Identify a skill or knowledge, list it, then as the skill or knowledge reoccurs merely indicate by use of a tic mark.

   b. Compile the categories for summarization rather than making a decision for each statement as you are going through the analysis.

   c. Develop a tally sheet form for the first task you analyze and add column for each new task you analyze. Extend the list of skills and knowledge as they are derived from the analysis.of the additional tasks.

Examples of a skills and knowledge clustering and tally sheet are provided at pages 35, 36, 37, 38, and 39.

4. Compile the results of the task analysis.

   a. Add the density of each skill and knowledge by task.

   b. List the skills and knowledge in their respective categories by task.

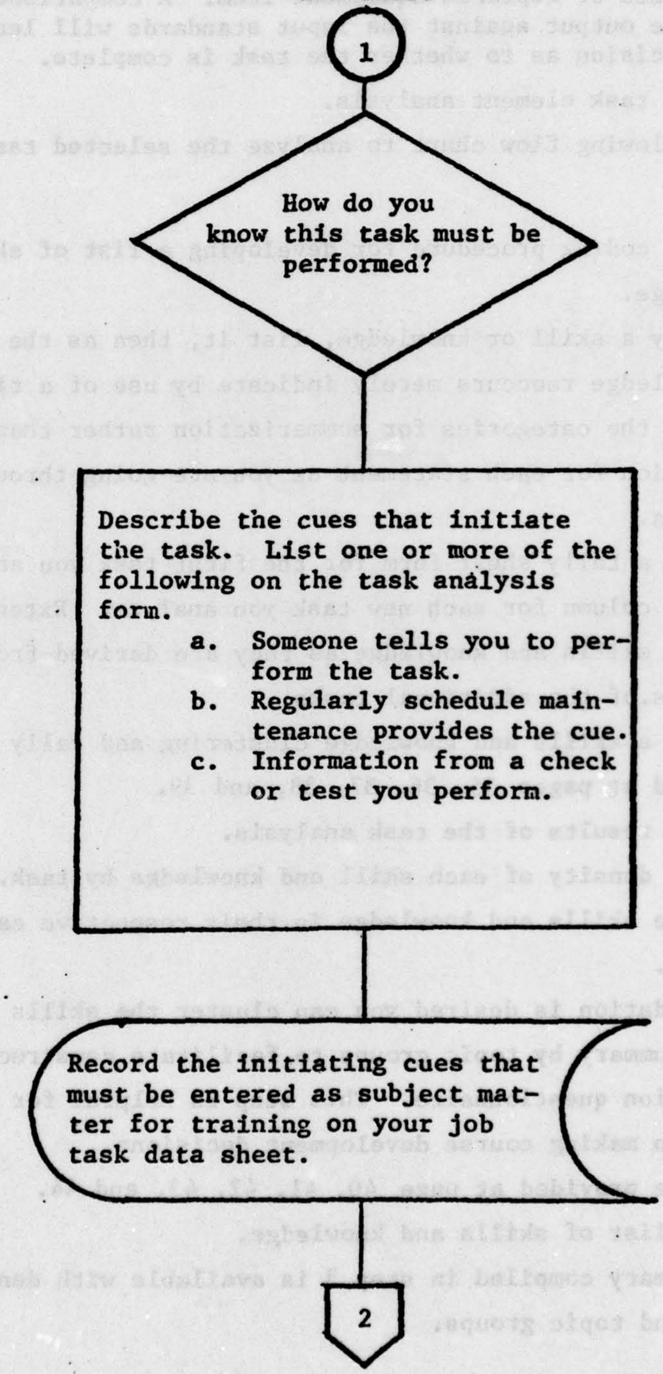
   c. If validation is desired you can cluster the skills and knowledge summary by topic groups to facilitate construction of a validation questionnaire. This step is helpful for review prior to making course development decisions.

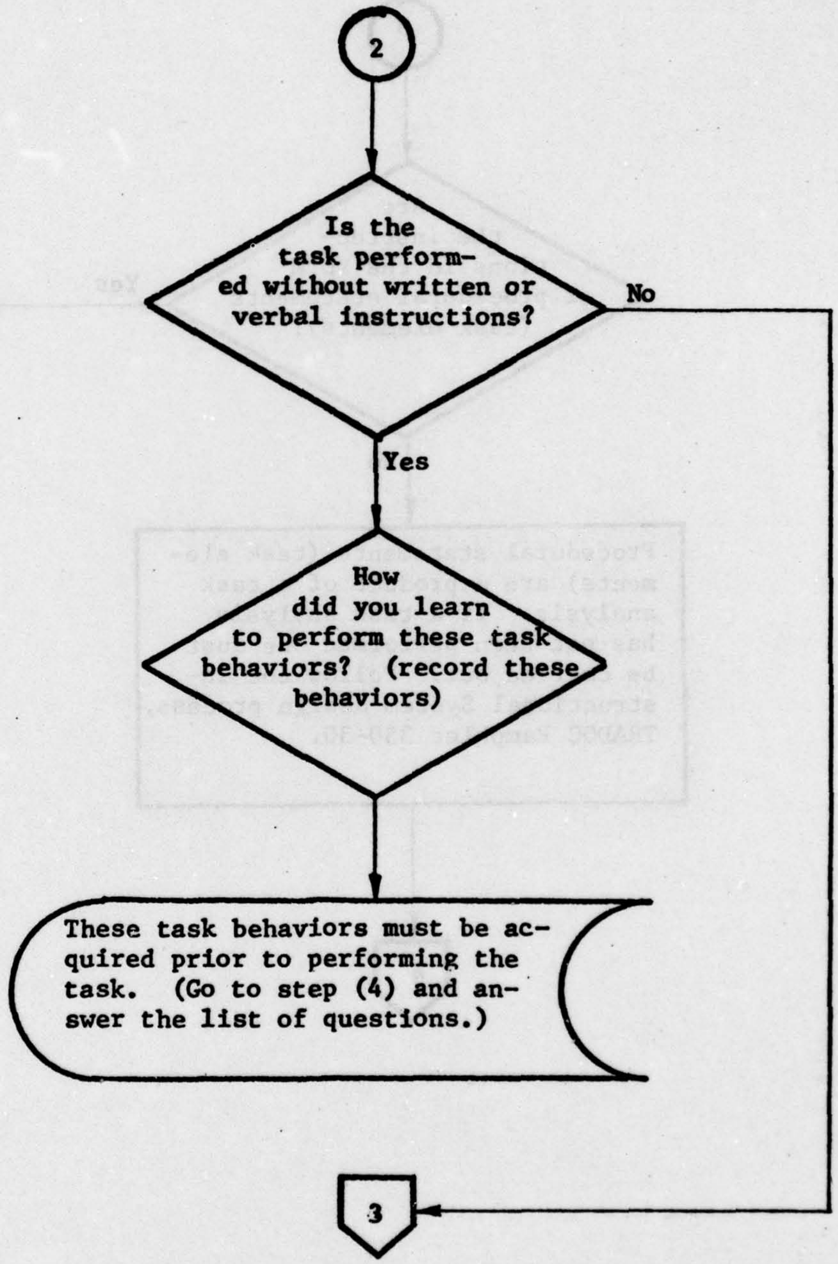
Examples are provided at page 40, 41, 42, 43, and 44.

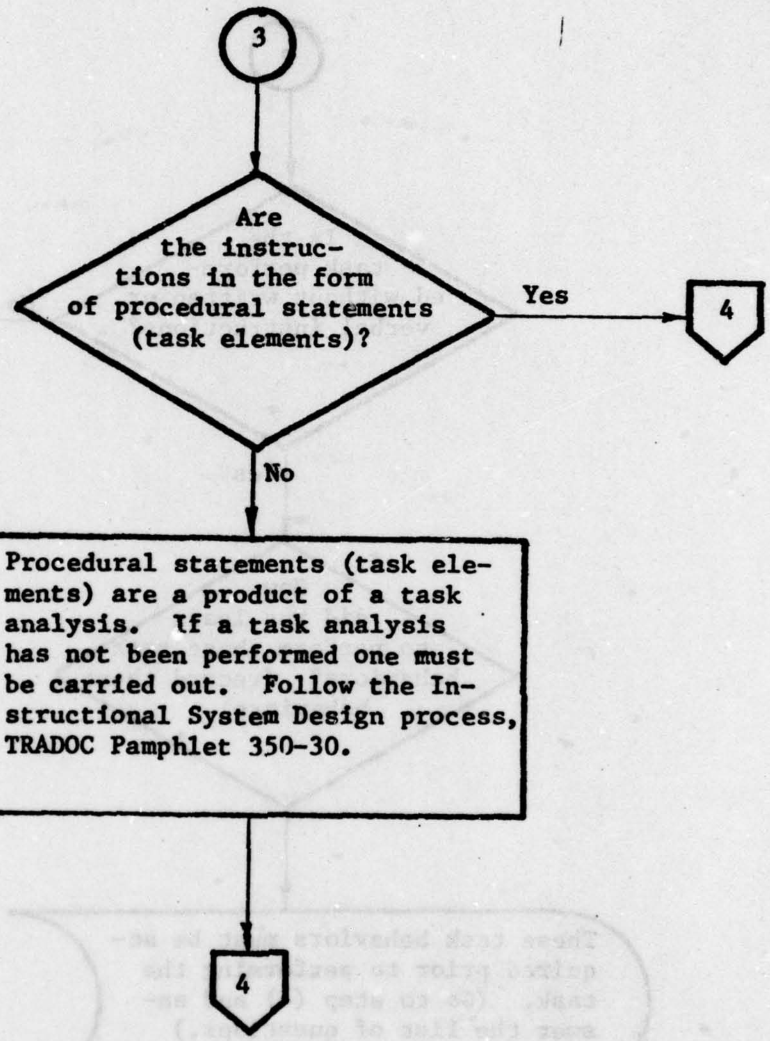
5. Review the list of skills and knowledge.

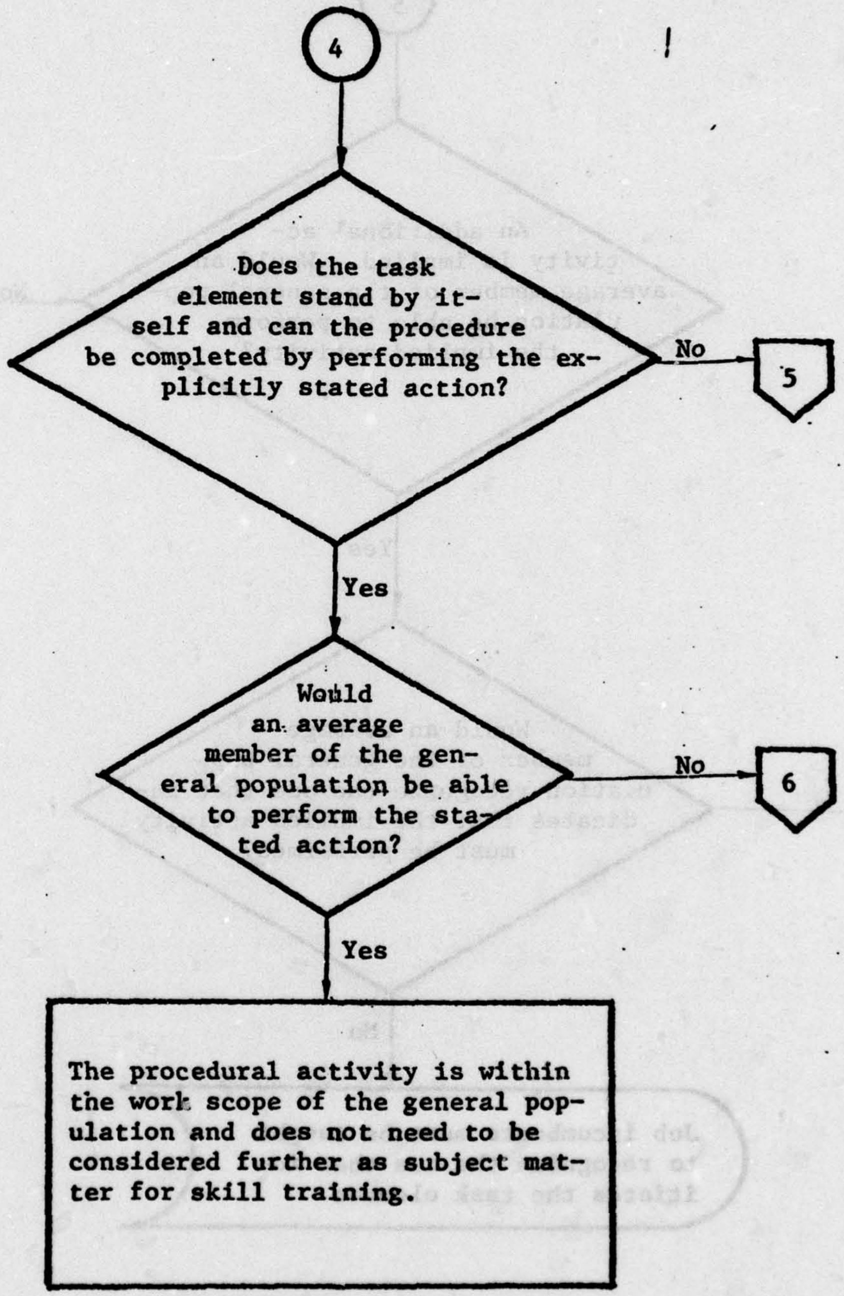
   a. The summary compiled in step 3 is available with density results and topic groups.

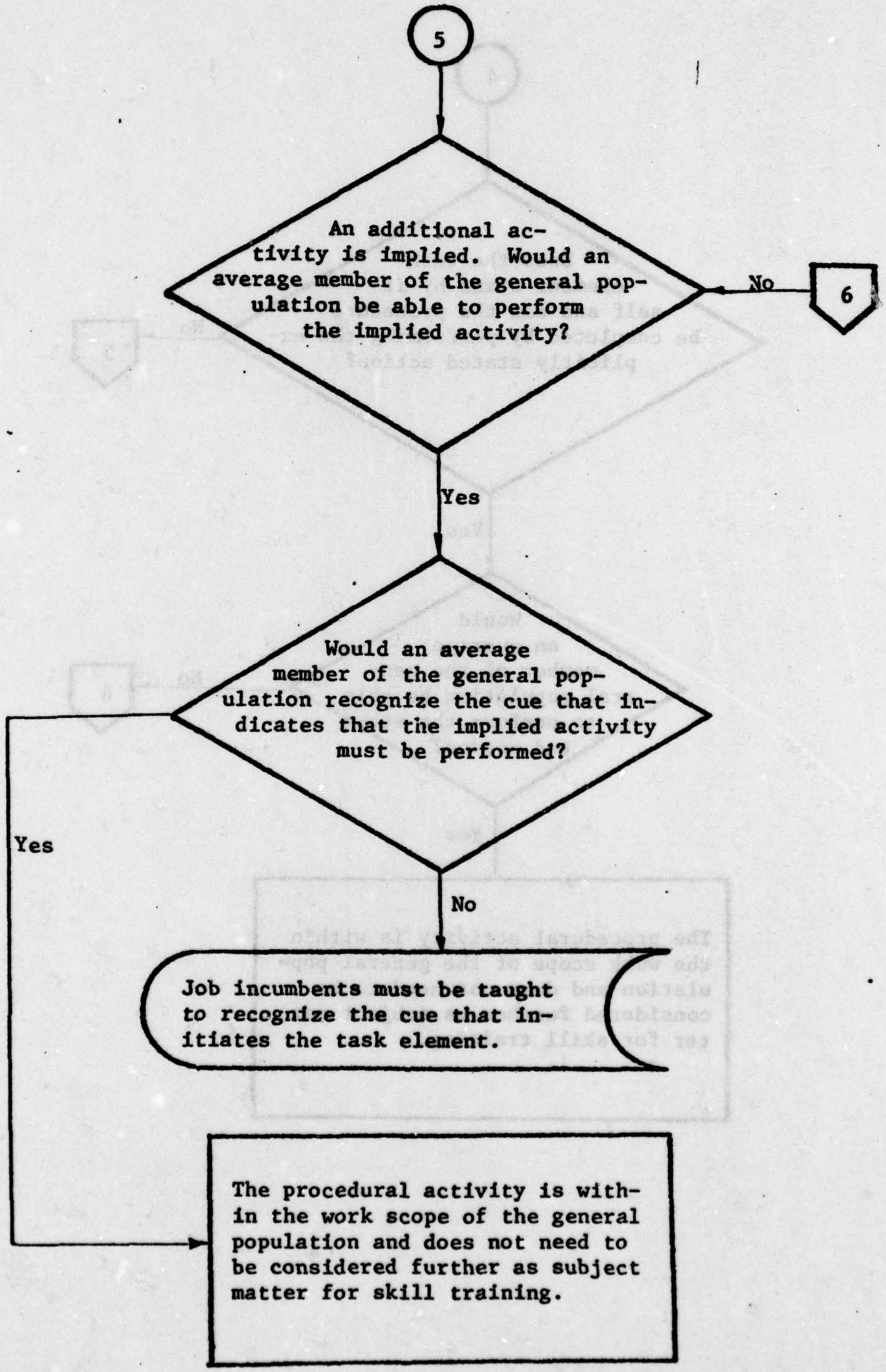
Task Analytical Process Model
Flow Chart

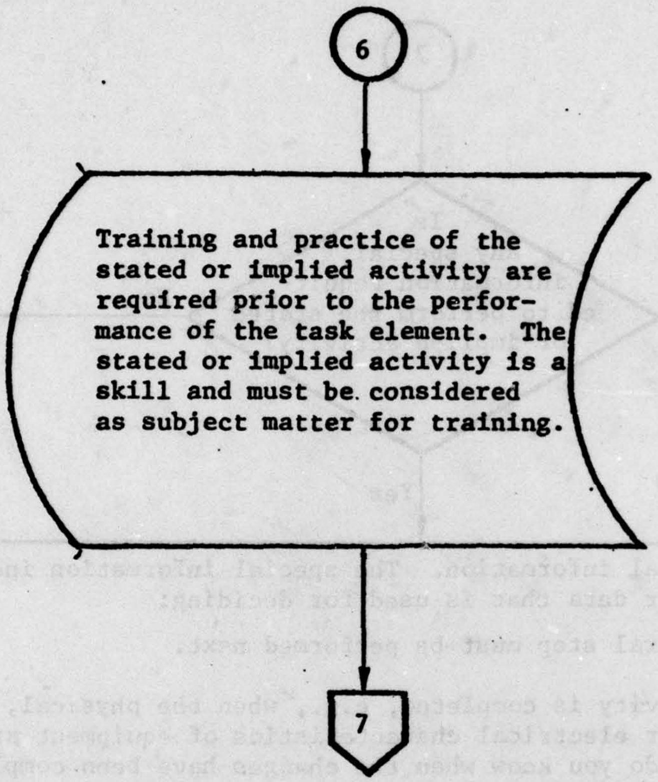


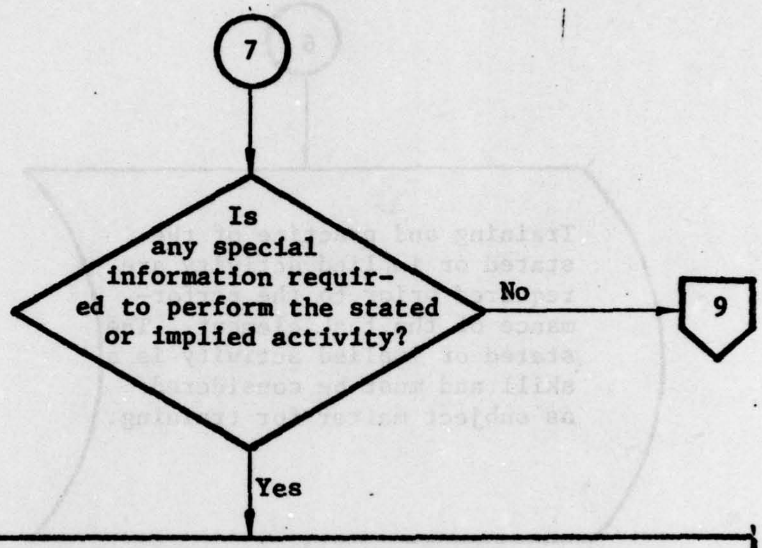

2
Is the task performed without written or verbal instructions?
No
Yes
How did you learn to perform these task behaviors? (record these behaviors)
These task behaviors must be acquired prior to performing the task. (Go to step (4) and answer the list of questions.)
3


3
Are the instructions in the form of procedural statements (task elements)?
Yes
4
No
Procedural statements (task elements) are a product of a task analysis. If a task analysis has not been performed one must be carried out. Follow the Instructional System Design process, TRADOC Pamphlet 350-30.
4


4
Does the task element stand by itself and can the procedure be completed by performing the explicitly stated action?
No
5
Yes
Would an average member of the general population be able to perform the stated action?
No
6
Yes
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


5
An additional activity is implied. Would an average member of the general population be able to perform the implied activity?
No
6
Yes
Would an average member of the general population recognize the cue that indicates that the implied activity must be performed?
Yes
No
Job incumbents must be taught to recognize the cue that initiates the task element.
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


6
Training and practice of the stated or implied activity are required prior to the performance of the task element. The stated or implied activity is a skill and must be considered as subject matter for training.
7



Record the special information. The special information includes any indication or data that is used for deciding:

1. What procedural step must be performed next.

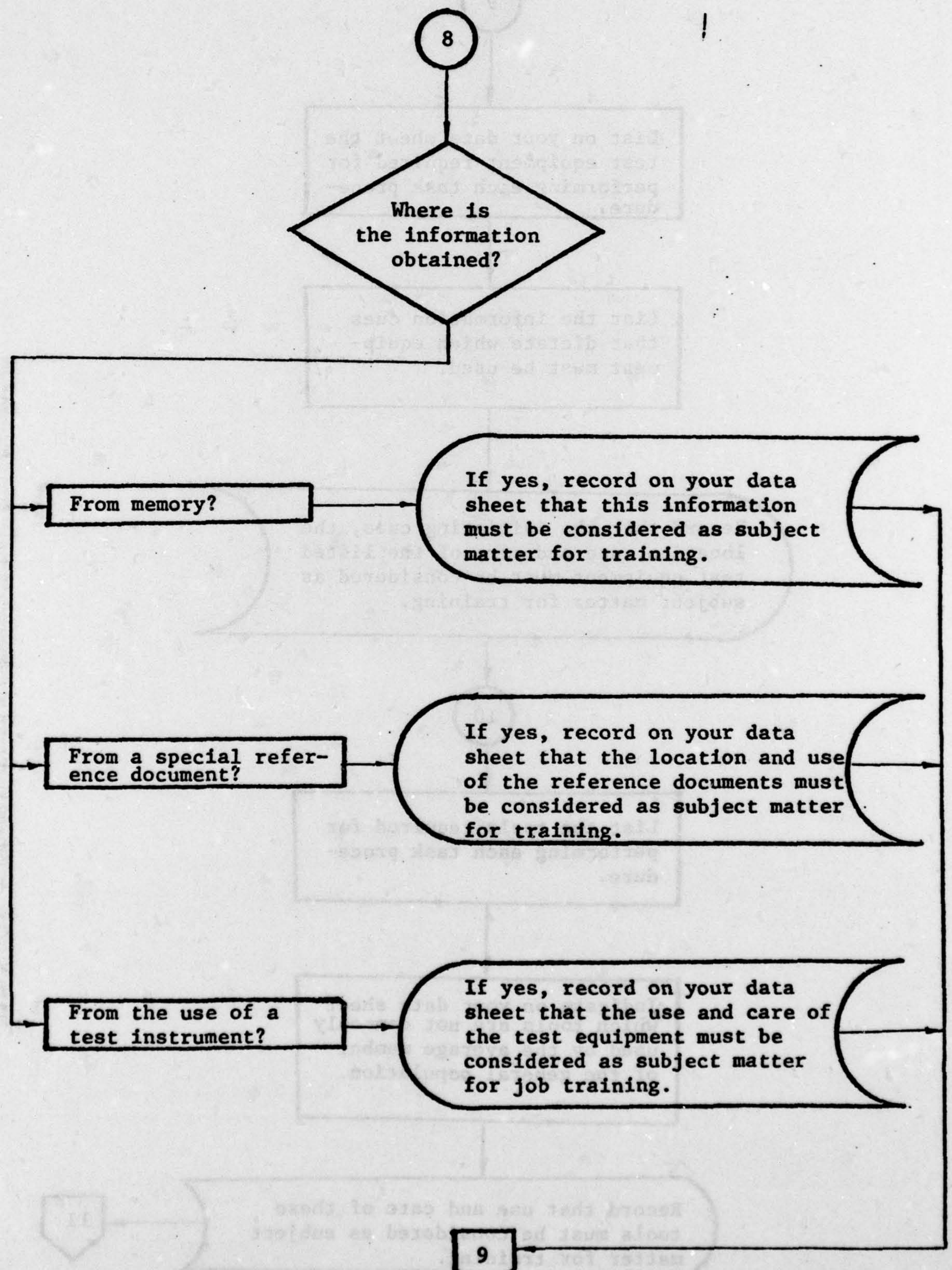
2. When an activity is completed, e.g., when the physical, mechanical or electrical characteristics of equipment are changed, how do you know when the changes have been completed? When the position of a switch has been changed the status or characteristics of the equipment item should be altered. The knowledge of what the expected changes should be is used to evaluate the result of turning the switch.

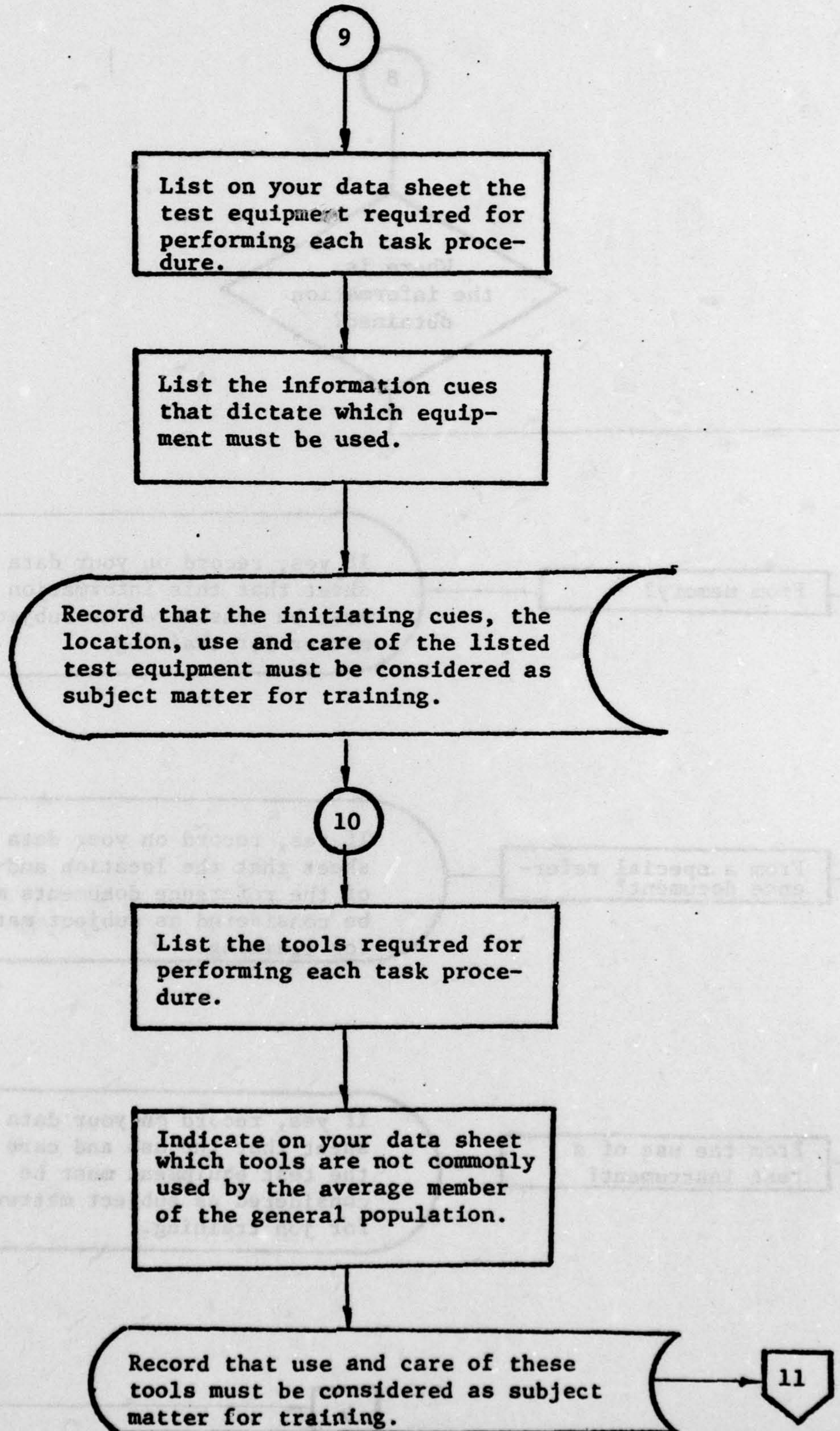
3. That a malfunction has occurred. If the expected status or characteristics change does not occur, something is not functioning properly.

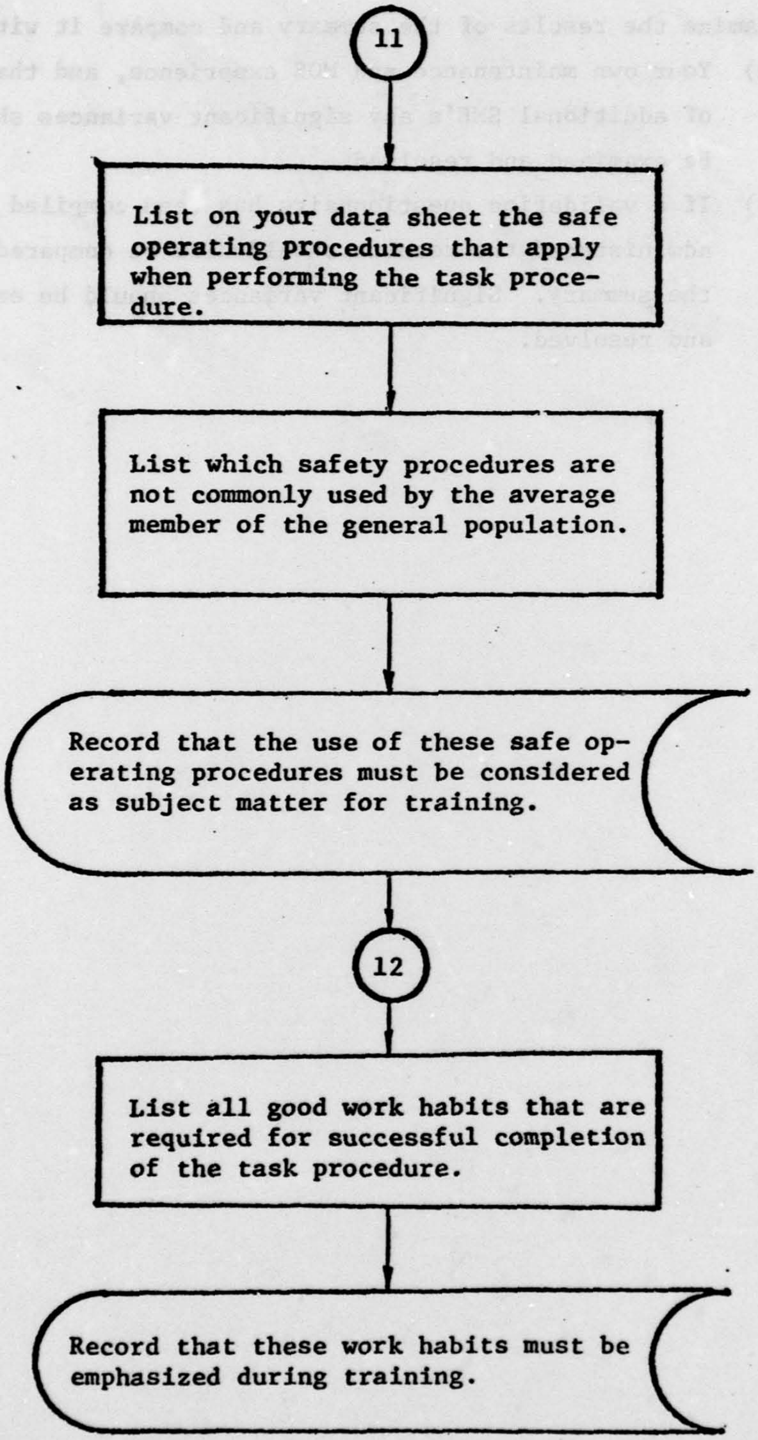
4. What the source of the problem may be. Does the evaluation of the information indicating a malfunction require a knowledge of:

   a. How the equipment functionally operates? and/or

   b. Why the equipment theoretically operates?


8
Where is the information obtained?
From memory?
If yes, record on your data sheet that this information must be considered as subject matter for training.
From a special reference document?
If yes, record on your data sheet that the location and use of the reference documents must be considered as subject matter for training.
From the use of a test instrument?
If yes, record on your data sheet that the use and care of the test equipment must be considered as subject matter for job training.
9


9
List on your data sheet the test equipment required for performing each task procedure.
List the information cues that dictate which equipment must be used.
Record that the initiating cues, the location, use and care of the listed test equipment must be considered as subject matter for training.
10
List the tools required for performing each task procedure.
Indicate on your data sheet which tools are not commonly used by the average member of the general population.
Record that use and care of these tools must be considered as subject matter for training.
11



11
List on your data sheet the safe operating procedures that apply when performing the task procedure.
List which safety procedures are not commonly used by the average member of the general population.
Record that the use of these safe operating procedures must be considered as subject matter for training.
12
List all good work habits that are required for successful completion of the task procedure.
Record that these work habits must be emphasized during training.

b. Examine the results of the summary and compare it with:

(A) Your own maintenance and MOS experience, and that of additional SME's any significant variances should be examined and resolved.

(B) If a validation questionnaire has been compiled and administered the results should also be compared with the summary. Significant variances should be examined and resolved.

Skills and Knowledge

Inventory

Uses Hand Tools

Screwdrivers - flat tip
Screwdrivers - cross tip (Phillips)
Hexagon headed - L shaped (Allen wrenches)
Open end wrenches
Rulers
Pliers
Torque wrenches
Thickness Guage
Dial indicators
Non magnetic tools and tuning wands

Uses Soldering Sets

Soldering Irons
Soldering Aids
Heat Syncs
Solder
Flux

Uses Electrical Test Components

RF Probes
Card Extractors
Attenuator Probes
Jumper Leads

Hardware

Gaskets (check, remove, replace)
Nuts and bolts (identify, check, remove, replace)
Identifies threaded - unthreaded holes

Hardware (cont.)

Index pins, (identify size and use)

Retaining clamps and screws (identify size, use, remove, repair, replace)

Turnlock fasteners

Set screws

Coaxial cables (connect, disconnect, check, repair, identify size and use)

TEE connectors (connect, disconnect, check, repair, identify size and use)

BSM connectors (connect, disconnect, check, repair, identify size and use)

Fuses (identify size, use remove, replace, check)

Lamps (light bulbs) (identify size, use remove, replace, check)

Wire (identify size, use, remove, replace)

Waveguides (identify size, use, remove, replace, repair, clean)

Dessicant (identify type, use, replace, repair container)

Filters - air and liquid (remove, clean, replace, identify size, use)

Coolant fluid and lubricants (identify type, uses, drain, refill)

Coaxial connectors (connect, disconnect, check, repair, identify size, use.)

Plugs, connectors, and jacks (connect, disconnect, check, repair, identify size, use)

Test Equipment

Uses - Multimeter URM 64A Signal Generator

Uses - Oscilloscope, USM 281C

Uses - Electronic Voltmeter, 300M

Uses TS-505 A/U multimeter

Uses TS-505 B/U multimeter

Uses TS-505 C/U multimeter

Uses TS-505 D/U multimeter

Test Equipment (cont.)

Uses - Multimeter URM 64A Signal Generator

Uses - Oscilloscope, USM 281C

Uses - Electronic Voltmeter, 300M

Uses TS-505 A/U multimeter

Uses TS-505 B/U multimeter

Uses TS-505 C/U multimeter

Uses TS-505 D/U multimeter

Uses AN/PSM6 multimeter

Insulates multimeter from metal portion of radar.

Recalls that case of the TS-505 A/U - B/U -C/U multimeters have a high positive potential.

Does not touch the case of the TS-505 A/U, B/U or C/U multimeter after leads are connected to test jack.

Grounds the TS-505 D/U multimeter when it is to be used and does not need to insulate it.

Set up meters for operation.

Determines oscillation as a movement at a steady rate between two limits.

Operate a stop watch.

Interprets meter reading as input decision for subsequent action.

Uses high frequency console/test equipment.

Multimeter A & B

Test Equipment (cont.)

Dual Pulse Generator

Oscilloscope

Multifunction Generator

Modulator Oscillator

600 Ohm Attenuators

Electronic Components

Uses (removes, replaces, selects) switches.

Adjusts variable resistors.

Locates physical position of components and chassis.

Aligns synchros.

Data and power cables (removes, replaces, checks, cleans)

Locates test points on equipment.

Locates ground points on equipment.

Adjusts controls to obtain proper indication.

Applies corrective action when indications of improper conditions occur.

Checks and replaces Cathode Ray Tubes (CRT).

Makes corrections and disconnections of various types of multi connector power, data and coaxial cables.

Capacitors (checks, removes, replaces.)

TALLY SHEET

SKILLS AND KNOWLEDGE ANALYSIS

SKILL OR KNOWLEDGE	CATEGORY	TASK #1	TOTAL	TASK #2	TOTAL	TASK #3	TOTAL
Performs alinement	B1		9		3		
Performs addition	B6				4		
Uses schematics	B8				6		
Installs gasket	B3						3
Uses wrench open end	B2						3
Uses electronic voltmeter	B4		9				
Obtains minimum meter indication	B4		9				
Removes & installs index pins correctly	B5		3				
Uses (remove, replace, select) switches	B7		6		3		4

Job Description Questionnaire
Basic Electronic and
Mechanical Skills and Knowledge

B2 Do you use or refer to the following electrical measurement units?

	Yes	No
1. Volts	____	____
2. Amperes	____	____
3. Ohms	____	____
4. Herz	____	____
5. Farads	____	____
6. Watts	____	____
7. Henries	____	____

B3 Do you work with the following electrical circuits?

	Yes	No
1. AC circuits	____	____
2. DC circuits	____	____

B4 Do you work with the following vacuum tube circuits?

	Yes	No
1. Amplifier circuits	____	____
2. Tuned (resonant) circuits	____	____
3. Cathode follower circuits	____	____
4. Multivibrator circuits	____	____

B4 (cont.)

	Yes	No
5. Power supply circuits		
6. Voltage regulator		
7. Oscillator circuits		
8. Sweep generator circuits		
9. Timing (pulse) circuits		
10. Display circuits		
11. Clamping (limiter) circuits		
12. Noise generator circuits		

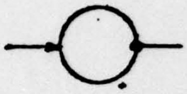
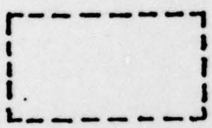
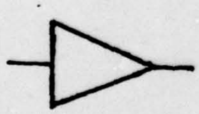
T10 Do you use the following tools in your maintenance duties?

	Yes	No
1. Screwdrivers - flat tip		
2. Screwdriver - cross tip (Phillips)		
3. Screwdriver - jewelers		
4. Hexagonhead wrenches (L bar, Allen)		
5. Open end wrenches		
6. Attenuator probes		
7. Jumper leads		
8. Rulers		
9. Pliers		
10. Wire strippers		

T10 (cont.)

	Yes	No
11. Pocket knife	___	___
12. Torque wrench	___	___
13. Soldering irons	___	___
14. Soldering sets	___	___
15. Soldering aids	___	___
16. Heat sink	___	___
17. Thickness gauge	___	___
18. Dial indicators	___	___
19. Non-magnetic tools	___	___
20. Tuning wands	___	___
21. RF probes	___	___
22. Card extractors	___	___

SC-14 Do you use and refer to the following schematic symbols?

	Symbol		Yes	No
1.		Denotes that component is adjustable	____	____
2.		Denotes slip ring	____	____
3.		Denotes buildup for variable resistors	____	____
4.		Denotes mechanical linkage or shielding	____	____
5.		Denotes general enclosure of functional grouping	____	____
6.		Denotes minor signal, arrow points in direction of signal flow	____	____
7.		Denotes major signal, arrow points in direction of signal flow	____	____
8.		Denotes amplifier	____	____
9.		Denotes system ground	____	____
10.		Denotes chassis ground	____	____
11.		Denotes common connector	____	____
12.		Denotes loudspeaker	____	____

EC34 If you work with power cables do you do the following? (If not, go on to EC35).

	Yes	No
1. Inspect them.	___	___
2. Remove/replace them.	___	___
3. Check (test) operation of them.	___	___
4. Repair them.	___	___
5. Fabricate them.	___	___

EC35 If you work with data cables do you do the following? (If not, go on to EC36).

1. Inspect them.	___	___
2. Remove/replace them.	___	___
3. Check (test) operation of them.	___	___
4. Repair them.	___	___
5. Fabricate them.	___	___

EC36 If you work with coaxial cables do you do the following?

1. Inspect them.	___	___
2. Remove/replace them.	___	___
3. Check (test) operation of them.	___	___
4. Repair them.	___	___
5. Fabricate them.	___	___